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Ontario Geological Survey
Open File Report 6177

# Geological Synthesis Along Highway 66 from Matachewan to Swastika

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ONTARIO GEOLOGICAL SURVEY

Open File Report 6177

# Geological Synthesis Along Highway 66 from Matachewan to Swastika

by

B.R. Berger

2006

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## MAP

Map 2677 Precambrian Geology, Highway 66 Area, Swastika to Matachewan........ back pocket

# Geological Synthesis Along Highway 66 from Matachewan to Swastika

B.R. Berger[1]
Ontario Geological Survey
Open File Report 6177
2006

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[1] Geoscientist, Precambrian Geoscience Section, Ontario Geological Survey

# Introduction

The area from Matachewan east to Swastika, along Highway 66, remains an attractive target for mineral exploration, even after 60 years of nearly continuous exploration activity. A project consisting of bedrock mapping and a geological synthesis was undertaken by the Ontario Geological Survey (OGS) to place the many diverse rock types, complex regional structures and numerous mineral showings into stratigraphic, structural and geochronological context. Detailed and reconnaissance bedrock mapping was carried out between 2000 and 2004 over an area bounded by 47°58'43" to 48°03'15" north latitude and 81°01'03" to 81°37'58" west longitude. All of Cairo, Holmes, Burt, Eby and Otto townships and parts of Flavelle, Alma and Gross townships were mapped (Figure 1). Paved highways 11, 65 and 66 are the major access routes and several gravel secondary and logging roads cover most of the townships. Only the most northern parts of Holmes and Alma townships were difficult to access. Matachewan, Swastika and Kirkland Lake are the closest communities to the map area (*see* Figure 1).

This report summarizes the bedrock mapping from 2000 to 2004 and combines this work with whole rock geochemistry, geochronology, petrography and magnetic susceptibility of rock units to provide a synthesis of the geology in the Highway 66 area. As stratigraphic correlation with lithotectonic assemblages proposed by Ayer et al. (2002) is poorly constrained west of Kirkland Lake, this was a major part of the synthesis. The regional Larder Lake–Cadillac deformation zone, several subsidiary and unrelated shear zones occur in the area (Lovell 1967; Moore 1966). The location, kinematics and mineralization associated with each structure was documented and interpreted with respect to the regional tectonic framework.

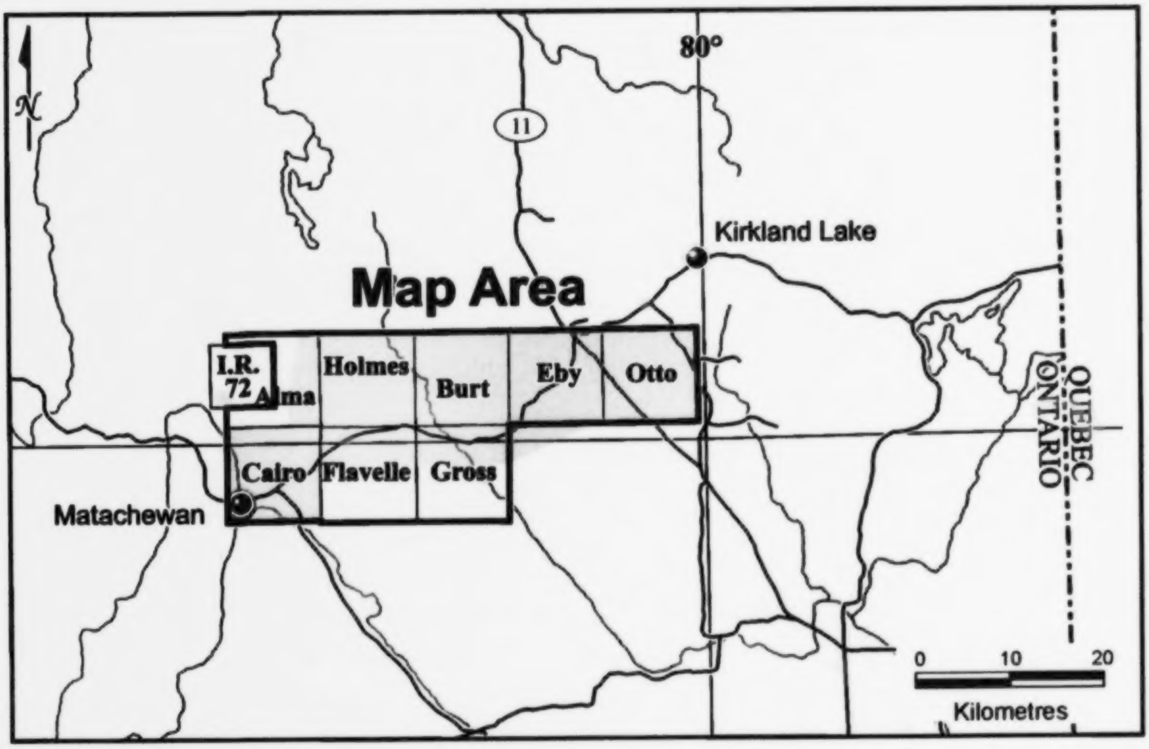


**Figure 1**. Location map for Highway 66 synoptic study.

## HISTORY OF EXPLORATION

Gold was first discovered on the west shore of Otto Lake in Otto Township in 1906 (Lovell 1972). This resulted in the discovery of the main Kirkland Lake gold deposits 5 years later and led to widespread exploration throughout the map area (Lovell 1967, 1972; Moore 1966). Discovery of gold, west of Matachewan, at the Young Davidson and Consolidated Matachewan deposits led to renewed exploration in the 1930s. Although several gold showings were discovered in the map area none were commercially exploited (Lovell 1967, 1972; Moore 1966). Copper, molybdenum, lead, barite and asbestos showings were also identified during the early exploration.

More recent exploration has concentrated on locating gold mineralization associated with structural features such as the western extension of the Larder Lake–Cadillac deformation zone, the Galer Lake fault and the Kincaid fault. Disseminated copper-gold mineralization occurs where these structures intersect the syenitic Cairo stock. A number of mining claims were in good standing at the time of writing and active mineral exploration was ongoing.

Exploration for base metals is reported in only a few parts of the map area. Zinc mineralization associated with interflow metasedimentary rocks was found by diamond drilling in northwest Cairo Township. Stringer copper mineralization hosted by tonalite occurs at the contact of the Round Lake batholith with supracrustal rocks in south Cairo Township. Disseminated copper mineralization occurs in gabbro sills and mafic metavolcanic flows in Cairo, Flavelle and Eby townships. Recently discovered copper, lead and precious metal mineralization associated with hydrothermally altered intermediate metavolcanic rocks is located in north Burt Township (Assessment Files, Resident Geologist's Office, Kirkland Lake).

## PREVIOUS GEOLOGICAL WORK

Lovell (1967, 1972) and Moore (1966) provide concise summaries of geological work in the synoptic map area prior to 1960 and readers are referred to this work for details. Regional geological maps by Cooke (1919, 1922) and Dyer (1935) were revised at greater detail by work carried out by Lovell (1967, 1972) and Moore (1966). Gerrie (1946) mapped the north part of Eby Township at 1:12 000 scale, which remains the most detailed government work that has been published. Jensen (1990) released an Open File Map (OFM 139) at 1:15 840 scale which includes parts of Burt, Holmes and Flavelle townships. Smith and Sutcliffe (1988) examined the Otto stock as part of their research into plutonic rocks in the Abitibi Subprovince. Kresz (1993) mapped Baden and Argyle townships to the northwest of the synoptic map area. Baker (1985) and Bajc (2000) mapped the Quaternary geology in the area.

Airborne geophysical data acquired through Operation Treasure Hunt (OGS 2000) and the Discover Abitibi Initiative (OGS 2004) encompass all or parts of the synoptic map area. These data and their derivative products (e.g., 2nd vertical derivative magnetic maps) were used to interpret the geology in overburden-covered areas and to locate the trace of structural features, especially under the Proterozoic Gowganda Formation. Copies of numerous private company airborne and ground geophysical surveys are on file with ERMES (Earth Resources and Mineral Exploration webSite) and in the assessment files at the Resident Geologist's Office, Kirkland Lake.

There are few theses, journal articles or academic studies that cover the synoptic map area. Lawton (1954) studied the Round Lake batholith and its satellitic intrusions. His work remains the only systematic study of the alkalic Otto stock. Powell (1991) and Powell and Hodgson (1992) examined deformation and metamorphism in the area with emphasis on Proterozoic reactivation of Archean structural features. Harrap and Helmstaedt (1992) studied the structure and emplacement mechanics of the Round Lake batholith. Chown, Harrap and Moukhsil (2002) discussed the role of the Round Lake batholith as part of the evolution of the Abitibi greenstone belt.

## PRESENT SURVEY

Geological mapping was carried out at 1:50 000 and 1:20 000 scale. Cairo Township (Leblanc and Berger 2002) and Eby–Otto townships (Pigeon and Berger 2004) were mapped at 1:20 000 scale in order to better subdivide the supracrustal rocks into coherent stratigraphic packages that could be correlated regionally. Holmes, Flavelle, Burt and Alma townships were mapped at 1:50 000 scale to verify rock units and structural features identified by Jensen (1990) and to correlate these units across the map area. Data were manually collected in the field and then entered into a digital database via CAD and FieldLog software programs.

The map area is characterized by typical Northern Ontario topography of areas of scattered outcrop interspersed with areas of swamp-, till- or esker-covered overburden. The average outcrop density is between 15 to 25% with some areas as high as 50% outcrop. Approximately 1530 outcrops were examined by members of the field crew over the 3 years. Large parts of southwest Eby and central Burt townships are extensively overburden covered with very little outcrop. Standard pace-and-compass traverses were supplemented with roadside and shoreline outcrop examinations. Several trenches and areas stripped for mineral exploration were examined in detail with respect to various aspects of mineralization and structure. Information on geology maps filed for assessment work credits (Earth Resources and Mineral Exploration webSite (ERMES) and Resident Geologist Office - Kirkland Lake) were incorporated onto Map 2677 (*see* back pocket) and data from diamond-drill core were included on the map where appropriate.

Data from airborne geophysical and regional ground surveys were used to aid interpretation of the geology (OGS 2000). Total field and 2nd vertical derivative airborne magnetic data, as well as regional gravity data, were used to trace magnetic units, to infer the location and offset of faults and to interpret the relative thickness of the Gowganda Formation.

## ACKNOWLEDGEMENTS

G. Leblanc served as senior assistant in 2002 and was responsible for mapping large parts of Cairo Township (Leblanc and Berger 2002). L. Pigeon served as senior assistant in 2003 and was responsible for mapping large parts of Eby and Otto townships. L. Greenlaw, M. Hay, L. Rajnovich, D.A. Trebilcock, C. Joulette capably served as assistants. Greenlaw, Hay and Rajnovich carried out some geological traverses.

Unless otherwise noted, all data for geochemical analyses presented in this report were provided by the Geoscience Laboratories (Geo Labs) in Sudbury.

# General Geology

## INTRODUCTION

The map area is part of the southern Abitibi greenstone belt of the Superior Province of the Canadian Shield. Neoarchean supracrustal rocks are composed of tholeiitic, calc-alkalic and alkalic mafic, intermediate and felsic metavolcanic rocks; related subvolcanic intrusions, chemical and clastic metasedimentary rocks. Ultramafic metavolcanic rocks occur locally. The supracrustal rocks are intruded by calc-alkalic intermediate and felsic intrusions composed of quartz diorite, quartz monzonite, tonalite and granodiorite. Alkalic intrusions composed of hornblendite, alkalic gabbro, syenite, quartz syenite and alkalic granite are the youngest Neoarchean intrusions in the area. The supracrustal rocks were correlated with regional assemblages described by Ayer et al. (2002).

Paleoproterozoic diabase dikes intrude the Neoarchean rocks and are correlated with the Matachewan swarm (cf. Osmani 1991). This dike swarm does not, however, intrude the Proterozoic Gowganda Formation, which unconformably overlies Neoarchean rocks and is composed of polymictic conglomerate, arkose, siltstone, argillite and wacke. Diabase dikes correlated with the Sudbury swarm (cf. Osmani 1991) intrude the Gowganda Formation and are present in Eby and Burt townships. Table 1 presents the major rock types in the Highway 66 synoptic area.

**Table 1**. Lithological units for Highway 66 area.

PHANEROZOIC
CENOZOIC
QUATERNARY
HOLOCENE
Lake, stream, wetland deposits
PLEISTOCENE
Glacial, glaciofluvial and glaciolacustrine deposits, sand, gravel, till and clay

*Unconformity*

PRECAMBRIAN
PALEOPROTEROZOIC
MAFIC INTRUSIVE ROCKS
Diabase dikes

*Intrusive contact*

HURONIAN SUPERGROUP
COBALT GROUP
Gowganda Formation
Sandstone, arkose, conglomerate, wacke, argillite, siltstone

*Unconformity*

MAFIC INTRUSIONS
Diabase dikes - quartz diabase, plagioclase porphyritic diabase

*Intrusive contact*

ARCHEAN
NEOARCHEAN
METAMORPHOSED ALKALIC FELSIC AND INTERMEDIATE INTRUSIVE ROCKS
Syenite, quartz syenite, monzonite, quartz monzonite, alkalic granite, feldspar and quartz feldspar porphyry, intrusion breccia, pegmatitic syenite, mylonite, schist, dikes, albitite and gneiss

*Intrusive contact*

METAMORPHOSED ALKALIC ULTRAMAFIC AND MAFIC INTRUSIVE ROCKS

Hornblendite, pyroxenite, equigranular and feldspar porphyritic melasyenite, pegmatitic melasyenite, lamprophyre, gabbro/diorite

*Intrusive contact*

METAMORPHOSED CALC-ALKALIC INTERMEDIATE AND FELSIC INTRUSIVE ROCKS

Tonalite, granodiorite, quartz monzonite, gneiss, pegmatite and aplite dikes

*Intrusive contact*

METAMORPHOSED ULTRAMAFIC AND MAFIC INTRUSIVE ROCKS

Peridotite, pyroxenite, gabbro, gabbro-norite, diorite, pegmatitic gabbro, schist

*Intrusive contact*

MAFIC AND INTERMEDIATE ALKALIC METAVOLCANIC ROCKS

Massive and porphyritic amphibole-biotite–bearing flows, flow breccia, pyroclastic and epiclastic tuff, lapilli tuff and breccia, schist, calc-silicate-altered units, amphibolite, feldspar porphyritic dikes

CLASTIC AND CHEMICAL METASEDIMENTARY ROCKS – TIMISKAMING ASSEMBLAGE

Wacke, sandstone, arkose, siltstone, argillite, polymictic conglomerate, schist, chert, laminated magnetite-hematite iron formation

*Unconformity*

CLASTIC AND CHEMICAL METASEDIMENTARY ROCKS – TURBIDITES

Wacke, siltstone, argillite, graphitic and pyritic argillite, schist, chert and conglomerate

FELSIC METAVOLCANIC ROCKS

Flows, autoclastic flow breccia, tuff, breccia, lapilli tuff, schist

INTERMEDIATE METAVOLCANIC ROCKS

Massive, flow laminated and pillowed flows, flow top and pillow breccia, tuff, lapilli tuff and tuff breccia, schist, graphite breccia, amygdaloidal, and variolitic units, feldspar porphyry

MAFIC METAVOLCANIC ROCKS

Massive and pillowed flows, pillow and flow top breccia, tuff and lapilli tuff, schist, variolitic and amygdaloidal units, plagioclase-bearing units, leucoxene-bearing units, graphite breccia and dikes

ULTRAMAFIC AND MAFIC METAVOLCANIC ROCKS (KOMATIITES)

Massive, spinifex- and polysuture-textured flows, schist, basaltic komatiite, variolitic flows

## PRECAMBRIAN

### Neoarchean

The Neoarchean supracrustal rocks are composed of ultramafic, mafic, intermediate and felsic metavolcanic rocks, related intrusive rocks, chemical and clastic metasedimentary rocks. Calc-alkalic intermediate and felsic intrusions composed of quartz diorite; tonalite, quartz monzonite, granodiorite, intruded the supracrustal rocks. Related gneisses and migmatites are developed adjacent to the intrusions and are locally metamorphosed to amphibolite facies. Alkalic intrusions composed of syenite, quartz syenite, albitite, clinopyroxenite, hornblendite, biotite-bearing gabbro and lamprophyre occur as stocks, dikes and small apophyses throughout the map area.

## ULTRAMAFIC AND MAFIC METAVOLCANIC ROCKS

Ultramafic and mafic metavolcanic rocks (komatiites) underlie the south part of Cairo and the north part of Otto townships and underlie approximately 1% of the map area (*see* map in back pocket). Komatiite occurs in 2 bands in Otto Township: a northern band, extending from the Amikougami fault west to Vigrass Lake, and a southern band of discontinuous thin flows approximately 1000 m south of the northern band (*see* map in back pocket). The northern band is up to 600 m thick and is composed predominantly of olivine spinifex and polysuture-textured flows. Pillowed and cumulate flows are rare. Talcose schist is common east of Otto Lake to the Amikougami fault and occurs as narrow, 1 to 10 m thick discontinuous units in northeast Otto Township. The ultramafic flows are truncated by the Larder–Cadillac deformation zone north of Vigrass Lake and occur as discontinuous carbonatized slivers and green mica schist intercalated with Timiskaming metasedimentary rocks within the deformation zone.

The southern band is composed of dark green weathering spinifex and polysuture-textured flows in close proximity to variolitic massive mafic flows. Spinifex blades are small (5 to 7 mm in length) and are extensively recrystallized to amphibole and epidote that is inferred to result from contact thermal metamorphism from the nearby Otto stock. The southern band is approximately 100 m thick and could not be traced for more than 1 km along strike.

Ultramafic metavolcanic rocks in Cairo Township are restricted to a small area east of Highway 65 and south of St. Paul Lake (*see* map in back pocket). Spinifex, flow brecciated and cumulate-textured flows form a narrow unit (less than 100 m thick) that was mapped for 2200 m along strike. Spinifex blades are generally less than 1 cm long and are extensively recrystallized similar to those ultramafic flows described above. A striking feature of the flows in Cairo Township is their close proximity to sulphide mineral-bearing iron formation. Blocks of iron formation up to 5 $m^2$ occur as rafts in the komatiite flows in a trench approximately 900 m south of St. Paul Lake. This indicates the potential for assimilation of country rocks and sulphur saturation of the ultramafic magma (Hill et al. 1990; Photo 1). Deposition of copper-nickel mineralization may occur in favourable channel facies of the komatiitic flows (Houle, Lesher and Sproule 2004).

Geochemistry for selected komatiitic flows and peridotites are presented in Table 2 (in Appendix). As komatiites were observed in only 2 parts of the map area, the following diagrams divide the samples into those from Cairo Township and those from Eby and Otto townships. Figure 2a shows that the selected samples follow the komatiite trend defined by Jensen (1976), with Cairo Township rocks generally less magnesium-rich than those from Eby and Otto townships. Figure 2b shows that almost all samples display similar major and trace element ratios that correspond to aluminium undepleted (AUK) komatiites (Sproule et al. 2002). AUKs are widespread throughout the Abitibi greenstone belt and are common in the Kidd–Munro, Tisdale and Stoughton–Roquemaure assemblages (Sproule et al. 2002). The isolated sample from Cairo Township falls into the aluminium-depleted field (ADK) but this sample is inferred to reflect crustal contamination as discussed below (*see* Figure 3a, b). Figure 3 shows rare earth element (REE) and extended trace element patterns for the various komatiites. One sample from Cairo Township displays elevated light rare earth elements (LREE) due to assimilation of country rocks and is unlike all other komatiites. This sample is inferred to be contaminated and as such represents a favourable host for komatiite-hosted copper-nickel mineralization.

**Photo 1.** Sulphide facies iron formation xenolith in spinifex-textured komatiite flow, Cairo Township. Hammer is approximately 35 cm long. Outcrop location UTM 531920 E, 5311119 N, NAD 83, zone 17.

## MAFIC METAVOLCANIC ROCKS

Mafic metavolcanic rocks underlie approximately a third of the map area and are concentrated mostly in Eby, Otto, Burt and Cairo townships. Fine-, medium- and coarse-grained massive flows are predominant throughout the map area. Flows are generally featureless, dark green-weathering rocks that may locally contain varioles, amygdules or plagioclase phenocrysts. However, well preserved columnar jointing is exposed in a trench excavated in Lot 4, Concession IV, Eby Township (Photo 2), where the joints pass into medium-grained, massive, equigranular basalt. This feature indicates that hot, thick magma ponds were part of the Archean environment.

Pillowed flows, pillow breccia and mafic tuff are subordinate members of the mafic metavolcanic rocks but may be locally important and more abundant than massive flows. Pillow shapes are generally well formed, close packed and range up to 1.5 m long by 0.5 m wide. In many places, however, pillows are small (50 by 30 cm) and may contain abundant interpillow material composed of chert and/or mafic hyaloclastite. A few locations in north Eby and north Otto townships have narrow pillow breccia units interlayered with flows. Mafic tuff is rare in the map area and, in most places, tuff and lapilli tuff identified in the field as mafic are petrographically or geochemically intermediate in composition.

Mafic schist refers to dark green-, black- or buff-weathering rocks that are fissile and fine grained. The protolith for these schists, other than mafic metavolcanic rock, is uncertain. Schist commonly contains calcium and/or iron carbonate in faults and deformation zones. Green mica, pyrite, pervasive and vein silicification is locally present, making these areas prospective for gold mineralization.

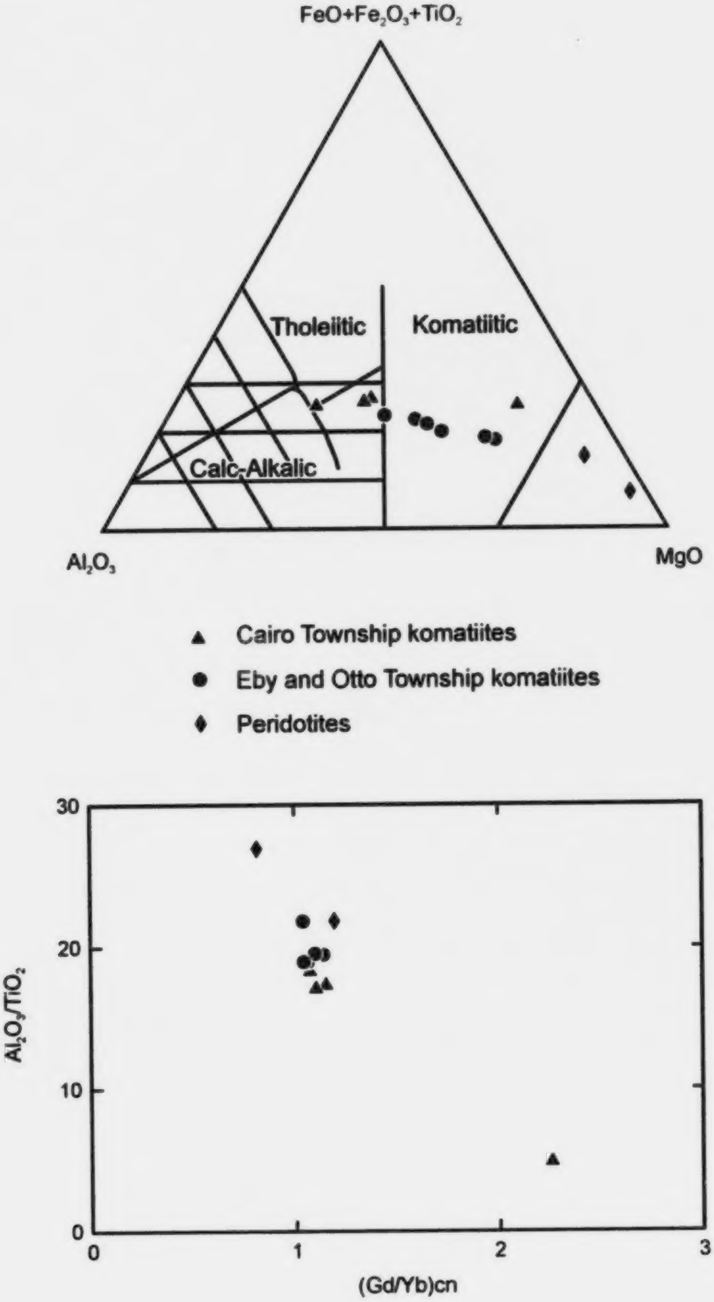


**Figure 2**. Geochemical discrimination of ultramafic rocks, Highway 66 area (cf. Sproule et al. 2002).

Many mafic metavolcanic rocks that occur in proximity to younger intermediate, felsic and alkalic plutonic rocks are affected by contact thermal metamorphism (the various rock types are portrayed on Map 2677 in back pocket). Amphibolite is a black-weathering, fine-grained, hornfelsic-textured rock that is very hard and commonly glassy. Primary textures, such as pillows, may be preserved but generally the rock is strongly recrystallized and massive. The rock contains a secondary mineral assemblage of amphibole-epidote-plagioclase and locally garnet. The absence or low percentage of chlorite in this rock type is inferred by the author to indicate amphibolite-grade metamorphic conditions.

Mafic gneiss and calc-silicate segregations occur adjacent to the Round Lake batholith and, in a few places, adjacent to the Otto stock. Mafic gneiss is characterized by centimetre-scale bands and segregations of epidote, feldspar and rarely garnet that are aligned parallel to the boundaries of the intrusions. White and pink, fine- to medium-grained tonalitic dikes and feldspar veins are commonly parallel and oblique to the banding, suggesting that the onset of partial melting occurred in conjunction

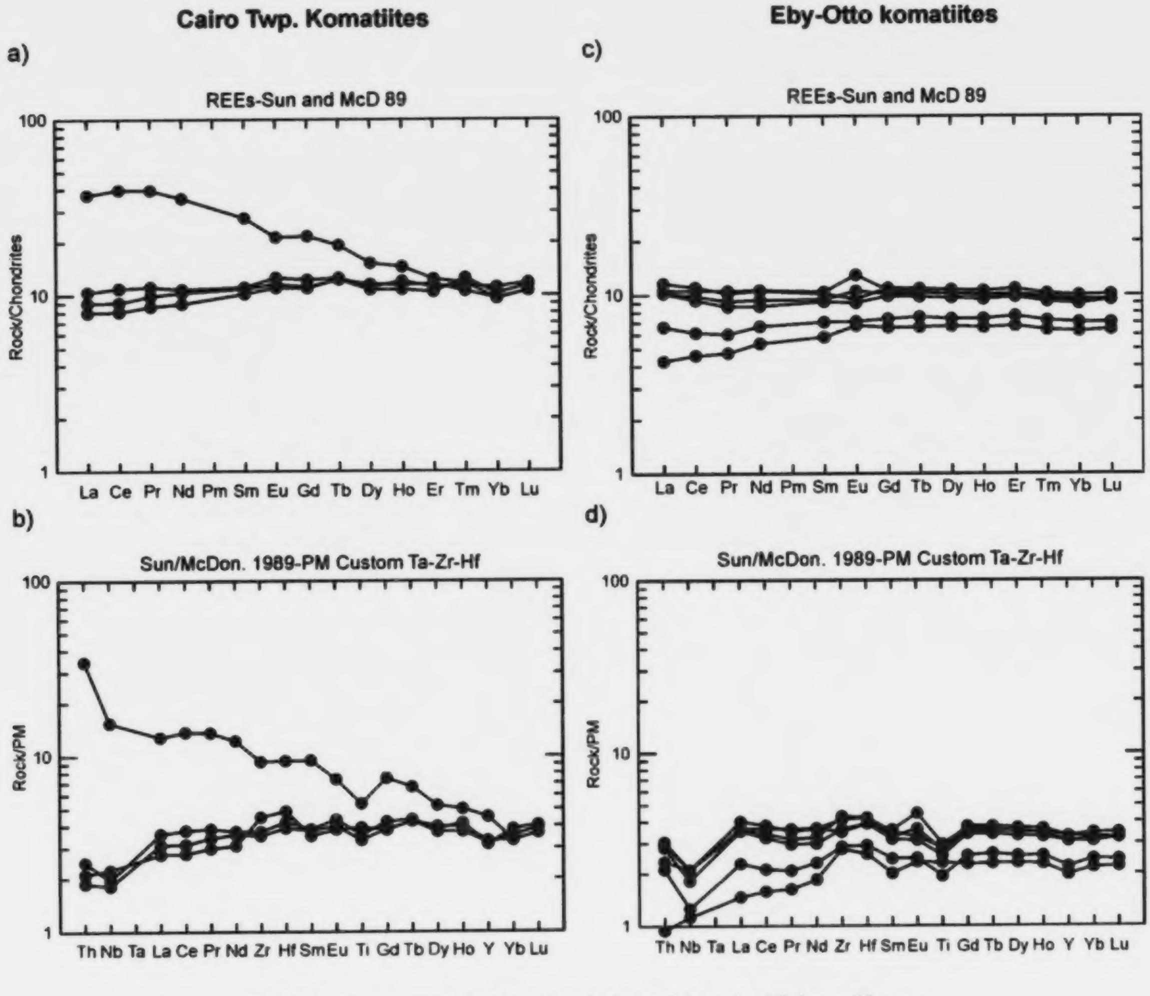


**Figure 3**. Trace element geochemistry for komatiitic rocks, Highway 66 area.

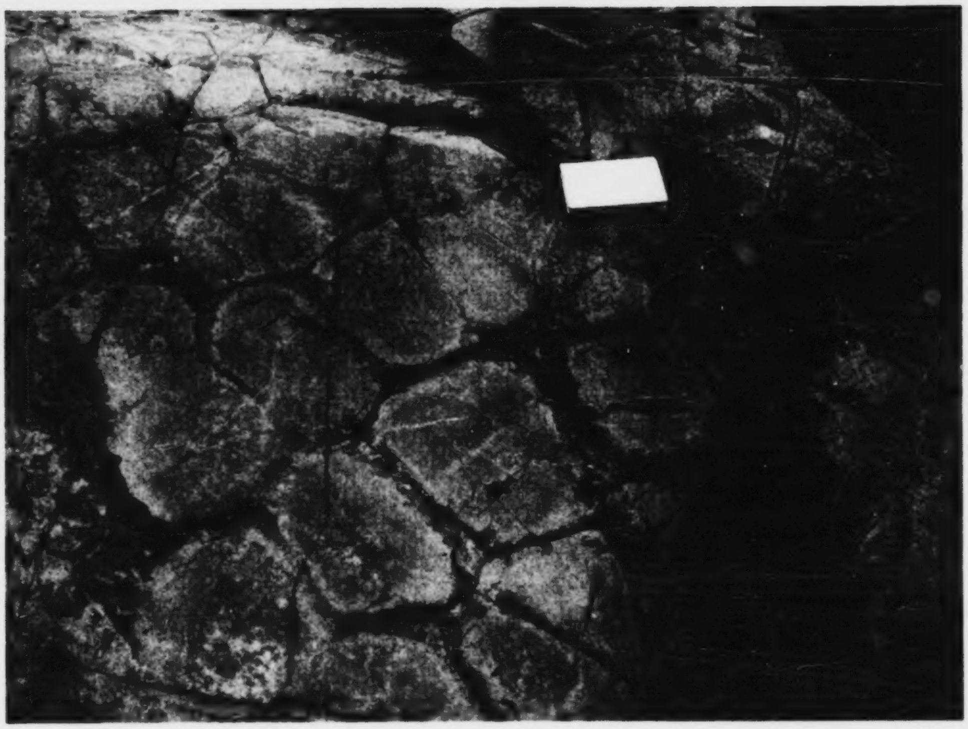


**Photo 2.** Columnar-jointed basaltic flow in Lot 4, Concession IV, Eby Township: a rare example of preserved primary features in mafic metavolcanic rocks in the map area. Outcrop location UTM 560909E, 5324167N, NAD 83, zone 17. Notebook is approximately 17 cm long.

with intrusion of the felsic plutons. Mafic and intermediate metavolcanic rocks that contain segregations, pods and veins with abundant calcium-bearing minerals such as epidote, calcite, amphibole and rarely garnet were mapped as calc-silicate altered. In many places this type of alteration is indistinguishable from mafic gneiss; however, locally the calc-silicate alteration is believed to result from metamorphism of hydrothermal alteration related to base metal mineralization (*see* "Mineralization"). The mineralogy is similar to those developed in skarn but the author prefers the term calc-silicate alteration since carbonate sedimentary rocks are not present in the map area (cf. Barnes 1979).

Geochemistry for representative mafic metavolcanic samples is presented in Table 3 (in Appendix). The mafic metavolcanic rocks are remarkably similar throughout the Highway 66 area and no systematic variations were observed. Samples range from magnesium-rich to iron-rich, low potassium tholeiite. REE and extended element variations indicate that most mafic flows are similar to enriched-mid ocean ridge basalts (E-MORB) with few normal-mid ocean ridge basalts (N-MORB) (Figure 4; Sun and McDonough 1989). These types of mafic metavolcanic rocks are typical elsewhere in the Archean (Ayer et al. 2002). It is likely that all mafic metavolcanic rocks belong to the same assemblage.

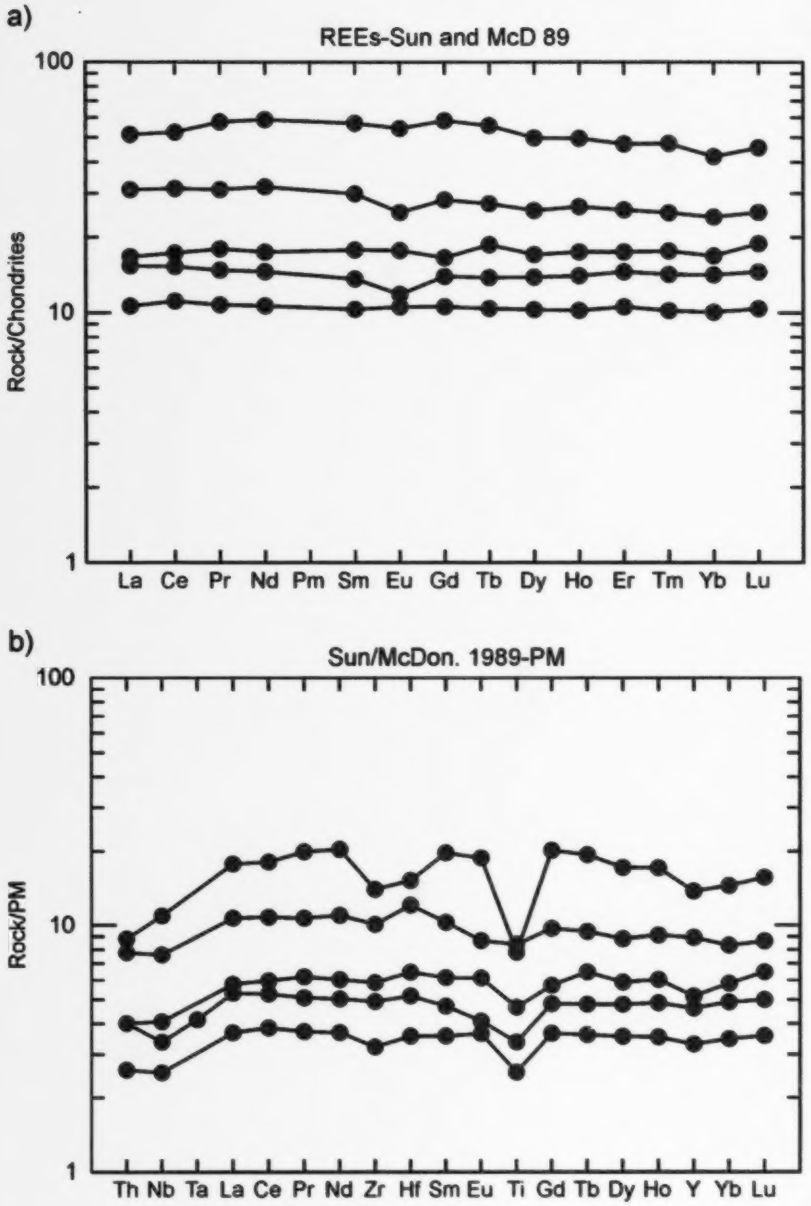


**Figure 4**. Trace element geochemistry for mafic metavolcanic rocks, Highway 66 area. Samples selected: 02-BRB-090, 02-BRB-238, JAA-00-198, 03-BRB-175 and 03-BRB-434.

## INTERMEDIATE METAVOLCANIC ROCKS

Intermediate metavolcanic rocks underlie 2 parts of the map area. Volcaniclastic deposits rarely interbedded with massive and pillowed flows occur in Eby, Burt, Flavelle and Cairo townships and are referred to as the "south band" in this report. Intermediate metavolcanic rocks composed primarily of lapilli tuff, tuff breccia, pillowed and massive flows also form a distinct mappable unit, referred to as the "north band" in this report, which underlies the northwest part of the map area. Intermediate rocks from each area are morphologically distinct.

The south band occurs as discontinuous units up to 750 m wide; however, in many places intermediate metavolcanic rocks form narrow units interbedded with units of mafic metavolcanic rock that are too small to be mapped at 1:20 000 scale. Epiclastic tuff, lapilli tuff, tuff breccia and rare flows underlie the east and central parts of the map area. Tuff, massive flows and schist underlie Cairo Township. The fragmental rocks are generally poorly sorted, matrix-supported units in which bedding and clast gradation is either poorly preserved or not well developed. Clasts are composed predominantly of feldspathic metavolcanic rocks with subordinate quartz crystals, bedded chert and mafic metavolcanic fragments. Rare tuff breccia with elongated and rounded clasts up to 15 cm in size occurs locally in Flavelle Township. Massive flows in Cairo Township are fine grained, equigranular, generally featureless and commonly recrystallized with abundant epidote, feldspar and secondary amphibole. These rocks generally have a colour index between 30 and 60% mafic minerals; however, where affected by shearing and/or contact thermal metamorphism a colour index as high as 75 was observed. Without the aid of thin sections or geochemistry the darker coloured rocks could be mapped as mafic metavolcanic rocks. Stratigraphic "tops" are poorly preserved but where observed (graded clasts and load casts) are conformable with the mafic metavolcanic rocks, suggesting that they are part of the same lithotectonic assemblage.

The north band of intermediate metavolcanic rocks is composed of tuff breccia, lapilli tuff and tuff interlayered with massive and pillowed flows. These rocks are characterized by white plagioclase phenocrysts and porphyroblasts up to 7 mm in size (Photo 3) although they may not be apparent in some flows and sheared rocks. The north band is poorly exposed and commonly highly strained, so details about bedding, flow morphology, and genesis are poorly constrained. The fragmental rocks are unsorted, poorly bedded and nongraded; however, unit thickness and contact relationships with other rock types were not observed. Massive and pillowed flows are subordinate to fragmental rocks and occur as narrow discontinuous units. Pillows are variable in size from approximately 50 cm to over 2 m long and are poorly to well formed. Rims are generally over 1 cm thick, with locally abundant vesicles, amygdules and gas cavities up to 2 cm in diameter. The feldspar phenocrysts are a reliable field indicator that these rocks have calc-alkalic geochemical affinity; the vesicles, gas cavities and abundance of fragmental deposits suggest gas-charged magmas were emplaced at shallow water depths or possibly subaerially. Reliable "top" indicators are poorly preserved and intrusive contacts with surrounding felsic and intermediate plutons obscure the stratigraphic relationships in the map area.

The north band of intermediate metavolcanic rocks extends west into Baden and Argyle townships. Kresz (1993) described rocks with similar fragmental and flow morphologies and indicated that the rocks contained dense plagioclase and pyroxene phenocrysts. Here the intermediate flows and fragmental rocks are folded about east-striking axes and overlie a suite of mafic metavolcanic rocks. The intermediate metavolcanic rocks are not dated; however, the author speculates that they may belong to the Blake River assemblage (~ 2700 - 2695 Ma, Ayer et al. 2002).

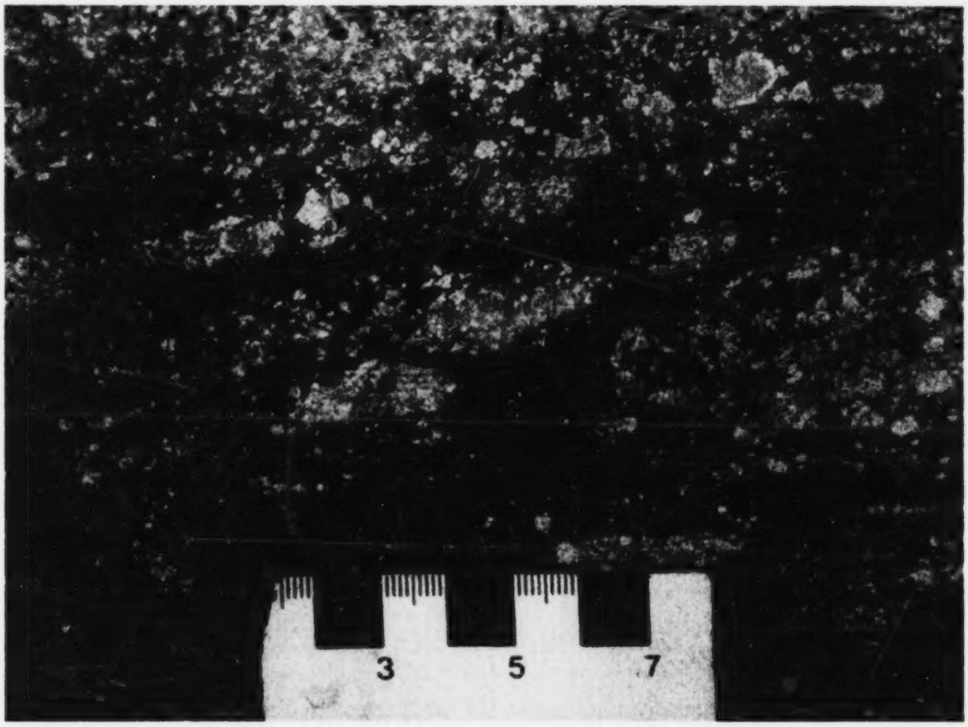


**Photo 3.** Intermediate metavolcanic tuff breccia from north Homes Township. The north band of intermediate metavolcanic rocks is characterized by abundant white feldspar phenocrysts and porphyroblasts. Outcrop UTM 537908E, 5322625N, NAD 83, zone 17.

Geochemistry for various intermediate metavolcanic rocks is presented in Table 4 (in Appendix). Figure 5 shows that all intermediate rocks are sub-alkalic andesite with only minor chemical variations among the different rocks. Figure 6 shows that intermediate metavolcanic rocks from Cairo Township are very similar to intermediate rocks from Flavelle and south Burt townships. It is likely that these rocks belong to the same assemblage. Rocks from north Burt Township contain slightly lower LREE, lower thorium and titanium than the other intermediate metavolcanic rocks, indicating that they most likely belong to a different assemblage (*see* Figure 6e, d). All intermediate rocks display negative niobium, tantalum and titanium anomalies commonly interpreted to represent derivation of magma by partial melting in a subduction zone (cf. Ayer et al. 2002).

Intermediate metavolcanic tuff interbedded with Timiskaming assemblage clastic metasedimentary rocks in Cairo Township has similar major oxide contents with other intermediate rocks in the map area; however, LREE content is much lower and nickel, chrome, cobalt and base metal contents are much higher (Table 4, sample 02-BRB-056). The limited aerial extent and the small number of samples preclude further discrimination of the intermediate metavolcanic rocks in the Timiskaming assemblage.

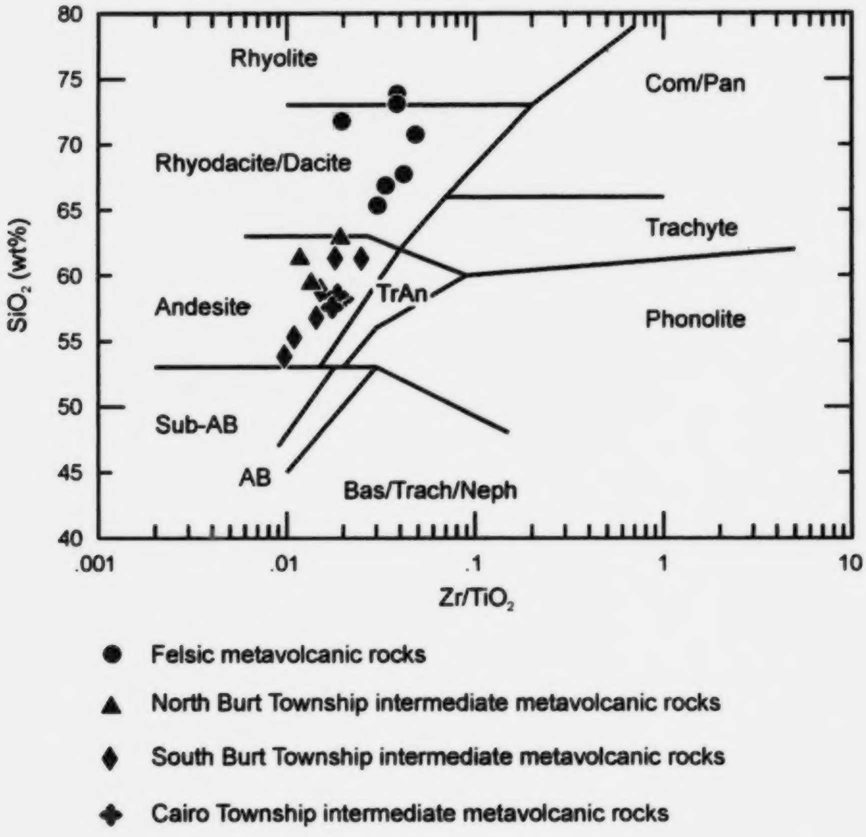
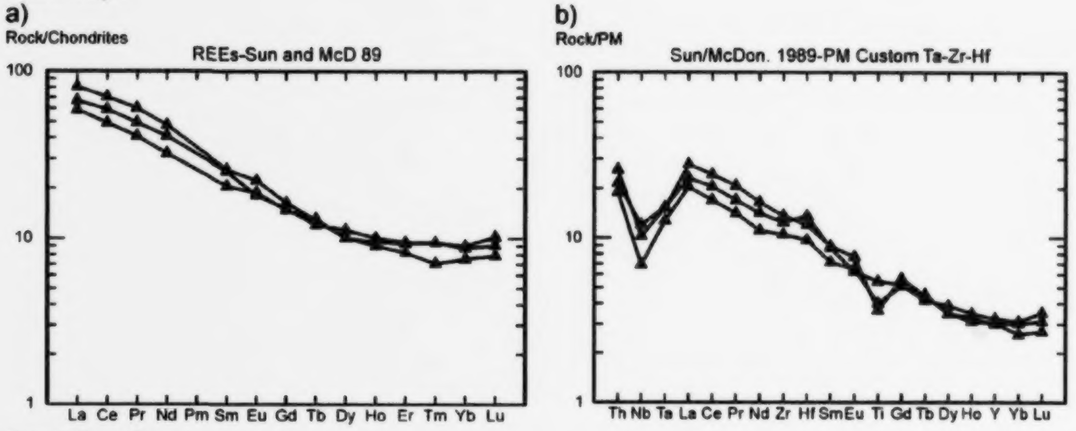
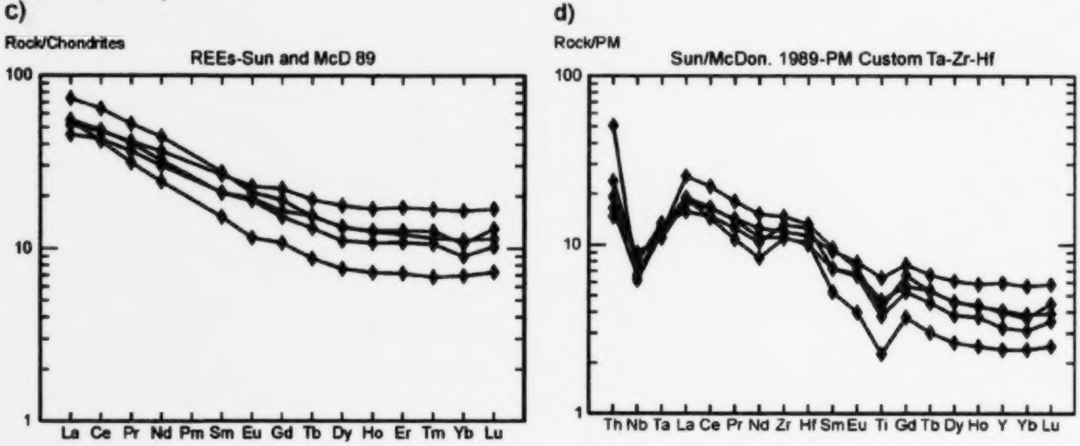


**Figure 5**. Classification of intermediate and felsic metavolcanic rocks, Highway 66 area (*after* Floyd and Winchester 1978).

**Cairo Twp.**



**South Burt Twp**



**North Burt Twp.**

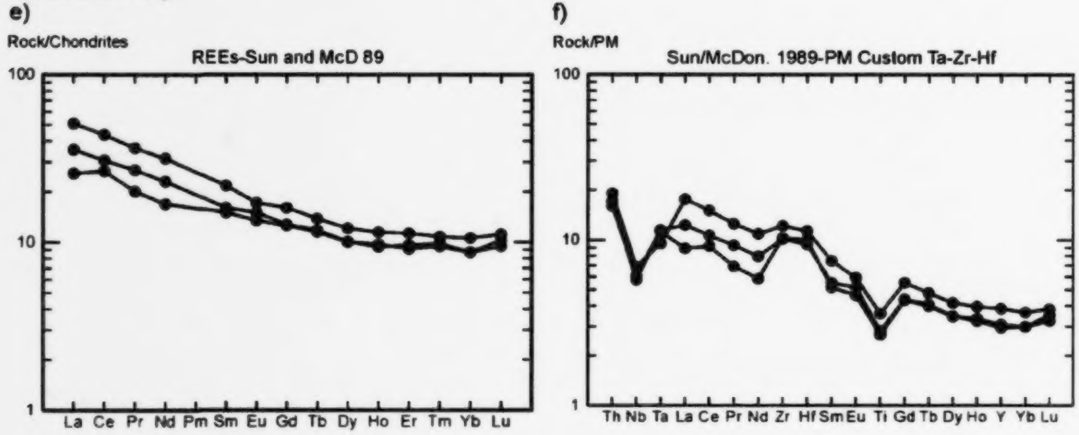


**Figure 6.** Trace element geochemistry for intermediate metavolcanic rocks, Highway 66 area.

## FELSIC METAVOLCANIC ROCKS

Felsic metavolcanic rocks comprise only a small percentage of the rocks in the map area and underlie parts of Cairo, Otto and Eby townships. Felsic metavolcanic rocks in Cairo Township occur as discontinuous flows and quartz-feldspar porphyry units of indeterminate origin. Buff, pink and white weathering, feldspar phyric rhyolite is exposed along Highway 66 approximately 1500 m east of Matachewan. Subhedral feldspar phenocrysts (2 to 5 mm), comprising 5 to 10% of the flow, occur in an aphanitic to cryptocrystalline groundmass. The flow is generally featureless but locally is brecciated and contains rounded lobes in what is inferred by the author to be chloritic hyaloclastite. The felsic unit is only exposed in few outcrops on the highway and along the Montreal River, so its full extent is unknown.

Quartz and feldspar porphyritic rocks occur as dikes, sills and small irregular intrusions in several places in west-central Cairo Township. These fine- to medium-grained rocks are white to yellow weathering and contain abundant quartz and feldspar phenocrysts. Primary features are obscured on weathered surfaces and it usually requires a cut surface or thin section to detect that many of these rocks have a fragmental texture with clasts of similar composition to the matrix. In thin section, euhedral and subhedral quartz and feldspar crystals occur in a fine-grained matrix composed largely of quartz, feldspar and white mica. It is possible that some of these units are extrusive, autoclastic flow breccia; however, further work is required to characterize these rocks. Kresz (1993) identified similar rocks west of the map area, where they occur as narrow sericitized and carbonatized dikes, commonly associated with gold mineralization.

Felsic metavolcanic rocks are associated with clastic and chemical metasedimentary rocks in Eby and Otto townships. These rocks may form narrow units interlayered with iron formation and wacke or may occur as lenticular units over 50 m thick, as in central Eby Township. Fragmental deposits of tuff and lapilli tuff are most common; flows are rare. Surface exposures are white to yellow weathering and are commonly white on fresh surface. The fragmental rocks form well to poorly sorted units that rarely display grain gradation and bedding planes. Maximum clast size is approximately 15 cm and clasts are composed of felsic metavolcanic rocks, cherty flow material and rarely sulphide minerals. The felsic rocks are predominantly epiclastic and are interpreted to have been deposited in a subaqueous environment distal to a vent. All felsic rocks associated with these deposits are strongly recrystallized and consist of fine-grained to cryptocrystalline quartz and feldspar with abundant secondary epidote, chlorite and white mica. Sieve-textured garnet, biotite and rare aluminosilicate minerals indicate that upper greenschist to amphibolite metamorphic conditions affected these rocks.

Geochemistry for the felsic metavolcanic rocks is presented in Table 4, Figure 5 and Figure 7. Dacite is most common, with rhyolite only exposed along the Montreal River and Highway 66 in south Cairo Township (*see* Figure 5). Figure 7 shows that rocks mapped as quartz-feldspar porphyry are geochemically similar to extrusive rocks and all rocks display negative niobium, tantalum and titanium anomalies. One sample (JAA-00-0018, Table 4) displays a REE and extended element patterns diagnostic of F-II rhyolite (*see* Figure 7a, b; cf. Lesher et al. 1986). Such rhyolite is known to host base metal deposits at Selbaie in Quebec and at Sturgeon Lake in northwestern Ontario (Lesher et al. 1986; Barrie, Ludden and Green 1993). The rhyolite in Cairo Township is in contact with sulphide mineral-bearing cherty iron formation but the author was not able to trace the felsic unit for more than 400 m along strike. A sample of rhyolite was collected for geochronology; however, no zircons were recovered. A multigrain titanite analysis is concordant at 2100 ± 16 Ma and points to a Proterozoic event that caused growth of new titanite in the rock (Figure 8). The absence of U-Pb zircon geochronology on the felsic metavolcanic rocks means that the author had to rely on regional correlation to assign these rocks to the Tisdale assemblage; readers are referred to Ayer et al. (2002) for further details.

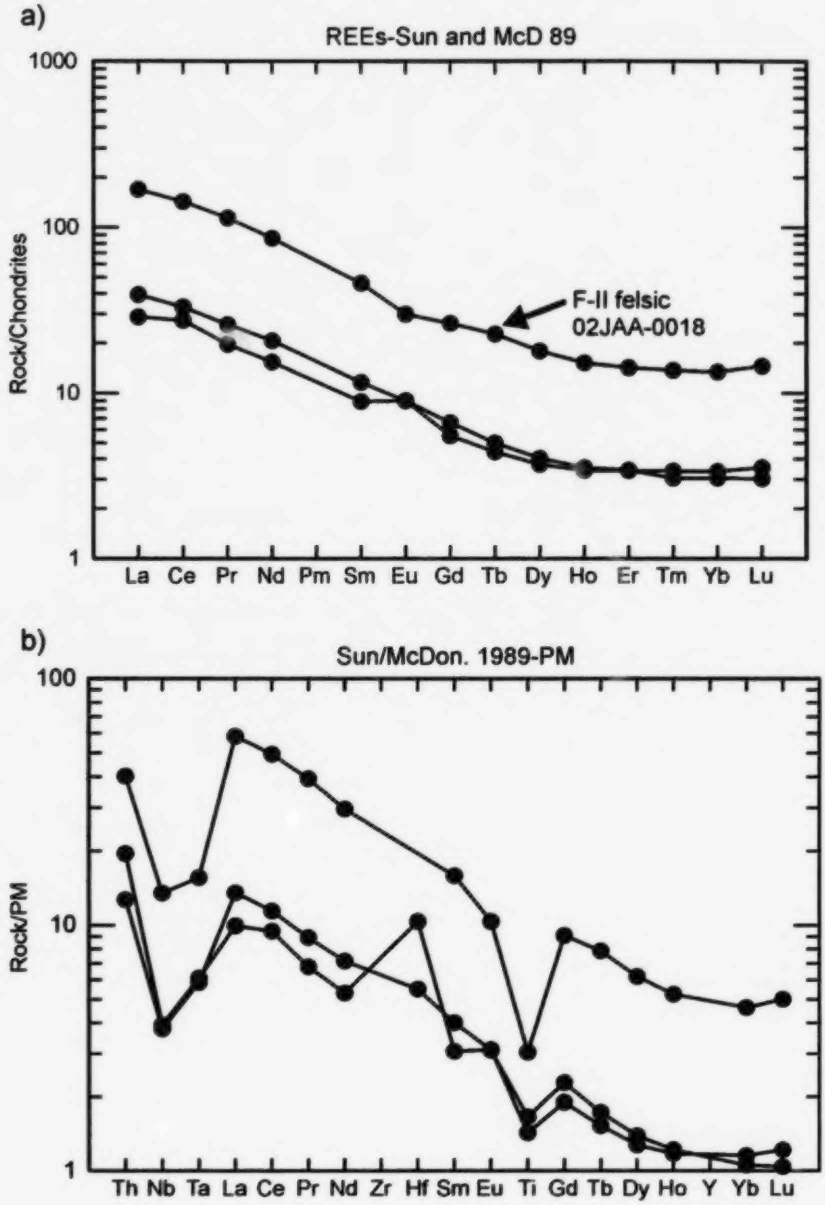


**Figure 7.** Trace element geochemistry for felsic metavolcanic rocks, Highway 66 area. Samples selected: 02-JAA-0018, 03-BRB-186, 03-BRB-427. See Table 6 (Appendix).

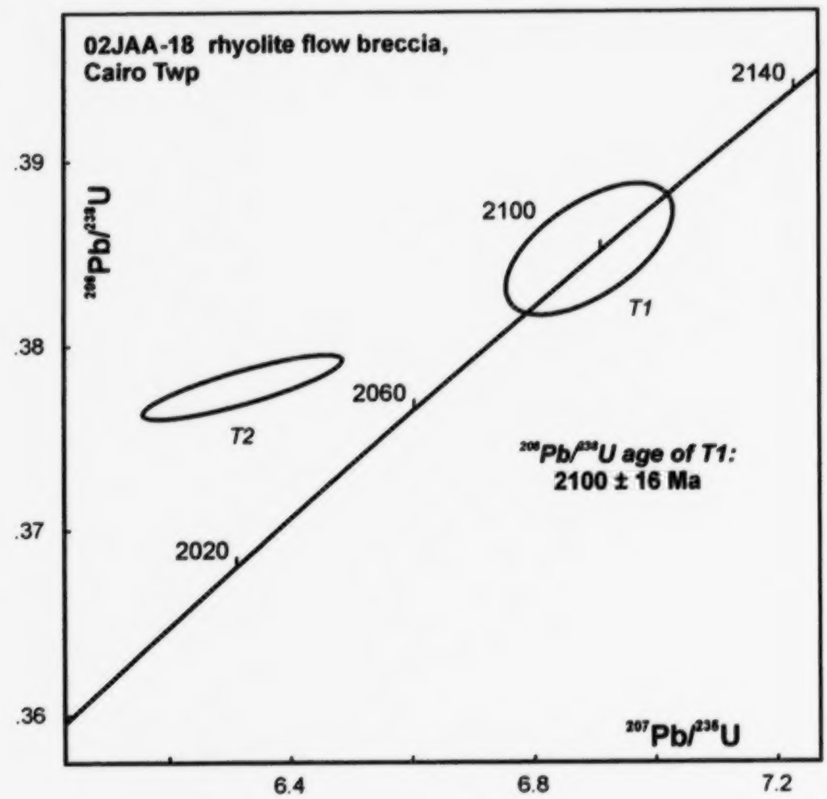


**Figure 8.** Geochronology for rhyolite sample in Cairo Township. Isochron for rhyolite in Cairo Township indicates a Proterozoic disturbance involving growth of new titanite. No zircons were recovered from this sample.

## CLASTIC AND CHEMICAL METASEDIMENTARY ROCKS

Neoarchean clastic and chemical metasedimentary rocks are subdivided into 2 assemblages for the purpose of this report. Wacke, siltstone, argillite, rare conglomerate, chert and magnetite-chert iron formation that underlie parts of Otto, Eby, Burt and south Flavelle townships are correlated with the Tisdale assemblage. Wacke, arenite and conglomerate interbedded with alkalic, intermediate and felsic metavolcanic rocks that underlie parts of Cairo, central Flavelle, Holmes and north Eby townships are correlated with the Timiskaming assemblage.

### Tisdale Assemblage

Metasedimentary rocks correlated with the Tisdale assemblage form discontinuous units ranging from 50 to over 200 m thick that extend from the east boundary of Otto Township to Flavelle Township. Laminated and thinly bedded magnetite-chert iron formation is dominant and is interbedded with wacke, argillite, graphitic argillite, and rare conglomerate. Felsic and intermediate metavolcanic rocks are interlayered with this unit in a few places. Sulphide facies iron formation occurs in south Cairo Township in association with wacke, chert, felsic and intermediate metavolcanic rocks and the author infers that these rocks are the continuation of the same stratigraphy in the west part of the map area.

White to grey chert occurs as finely laminated beds up to 15 cm thick that are interbedded with black magnetite beds of similar thickness (Photo 4a). These chemical metasedimentary rocks can be traced either on the ground or by geophysical airborne magnetic surveys (OGS 2000) from Otto to Flavelle townships. The geophysical surveys also show that the iron formation is contiguous with similar iron formation that formed the Adams iron ore deposit approximately 5 km east of the map area. Here, a felsic breccia immediately below the iron formation yielded a U-Pb zircon age date of 2710 ± 3.9 Ma, confirming a Tisdale assemblage correlation (Ayer et al. 2002). Fine-grained wacke and argillite are interbedded with the iron formation and locally form mappable units, as in north Otto and east Eby townships (Photo 4b). Local preservation of such primary features as grain gradation and load casts suggest that these rocks were formed by turbidity currents. Graphitic and pyritic argillite occurs intermittently throughout the unit; however, economic sulphide mineralization has yet to be discovered with any of these rocks. Clast-supported conglomerate was observed at 2 locations in this unit and contains clasts up to 30 cm in diameter composed of wacke, felsic and mafic metavolcanic rocks in a wacke matrix. Sulphide facies iron formation occurs in Cairo Township and consists of semi-massive and stringer pyrite beds interlayered with argillite and chert (Photo 4c). Pyrite can make up to 50% of the rock but more commonly comprises 15 to 20%.

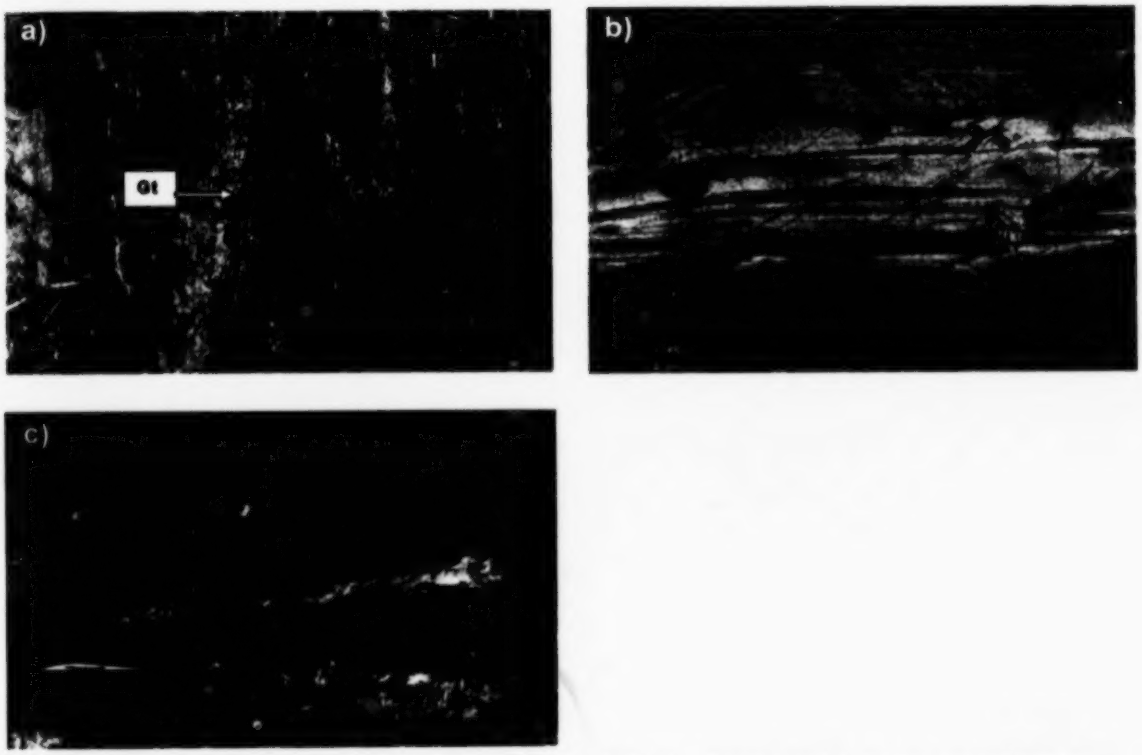


**Photo 4a.** Magnetite chert iron formation is the most common chemical metasedimentary rock in the map area and forms a discontinuous unit in the central part of the map area. Garnet (Gt) is a common metamorphic mineral. Pen magnet is 12 cm long. Outcrop in Otto Township at UTM 573097E, 5325640N, NAD 83, zone 17. **4b.** Laminated to thinly bedded wacke and argillite are commonly interbedded with the chemical metasedimentary rocks (*see* Photo 4a). Preservation of primary structures is rare. Pen is 15 cm long. Outcrop located in Otto Township, UTM 570129E, 5327730N, NAD 83, zone 17. **4c.** Sulphide facies iron formation occurs in Cairo Township and appears to be a lateral facies change of the magnetite-chert facies (*see* Photo 4a). Knife is 8 cm long. Outcrop in Cairo Township UTM 531583E, 5311145N, NAD 83, zone 17.

Several discontinuous metasedimentary units composed of chert, graphitic and pyritic ironstone and siliceous siltstone are interbedded with mafic metavolcanic rocks in Eby and Otto townships. The thickest (80 m) of these units is exposed along Highway 11 in Eby Township where thinly bedded pyritic and graphitic siltstone and chert is interlayered with mafic flows and massive peridotite. The contacts appear conformable and the author interprets this as representative of an exhalative environment during volcanic quiescence. Such environments are conducive for accumulation of base metal mineralization and komatiite-hosted copper-nickel deposits.

## Timiskaming Assemblage

The Timiskaming assemblage is composed of fine- to coarse-grained wacke, feldspathic and lithic arenite, conglomerate and minor argillite. These rocks are distinctly more quartz rich than clastic metasedimentary rocks described above and contain detrital microcline that is apparent only in thin section. The Timiskaming arenite also contains up to 10% lithic clasts, some of which are trachytic textured similar to alkalic flows and flow breccia observed in Eby Township. Primary structures include rare grain gradation, load casts and planar cross-beds. In one outcrop on the CNR railroad in Grenfell Township, approximately 250 m north of the map area, planar cross-stratification is developed in sandstone with 20 to 25 cm thick tabular sets with 20 to 30 cm long asymptotic foreset beds 0.5 to 1 cm apart. Such bed forms are commonly interpreted to form in alluvial-fluvial environments (Blatt, Middleton and Murray 1972).

Conglomerate occurs throughout the Timiskaming assemblage but is most abundant in the east part of the map area. In Eby Township clast-supported pebble and boulder conglomerate crops out along Highway 66 and south of Kenogami Lake. Clasts up to 30 cm in diameter are composed of mafic metavolcanic rocks, quartz and feldspar porphyry, trachyte, jasper-bearing iron formation, sulphide minerals and wacke and are set in a medium- to coarse-grained sand matrix. The angular to rounded clasts are poorly sorted, ungraded and occur as narrow bands a few centimetres thick to massive units over 25 m thick. Pebbly conglomerate and grit-sized sandstone is interbedded with boulder conglomerate at the junction of Highways 66 and 11 in Eby Township. These beds are commonly graded and dominated by mafic metavolcanic detritus to 1.5 cm in size suggesting that volcanism was episodic during Timiskaming sedimentation.

Pebble to boulder conglomerate deposits occur in structurally disrupted lenses along the south and east contacts of the Cairo syenite stock in Cairo and Holmes townships. Outcrops along Highway 66 display clast-supported boulder conglomerate with clasts up to 25 cm in size. Syenite, similar to that observed in the Cairo stock, is the dominant clast type but chert, wacke, sulphide mineral and aphanitic felsic metavolcanic clasts were also observed. The clasts generally decrease in size to the north and tend to become predominantly felsic in composition at this location. Clast-supported conglomerate dominated by rounded syenite cobbles occurs in a narrow unit along Tully Lake in Holmes Township and is gradational along strike into bedded alkalic tuff, siltstone and argillite. The dominance of syenite and metavolcanic cobbles in the conglomerate indicate that these are locally derived deposits and that the Cairo stock was eroded during the Timiskaming. A further implication is that the intercalated alkalic metavolcanic rocks are correlative with the Timiskaming and therefore younger than the Cairo stock (see below).

Metasedimentary rocks in west Cairo Township extend west of the map area into Powell Township where the youngest detrital zircons were dated at 2689 ± 3.1 Ma, correlative with the Timiskaming assemblage (Ayer et al. 2002). The rocks in Cairo Township are composed of wacke, lithic arenite, minor siltstone and rare volcaniclastic conglomerate. Generally light brown to grey weathering, these mediumto fine-grained rocks are commonly poorly to well bedded and display poor preservation of primary structures. In thin section, typical arenite contains greater than 25% quartz, approximately 1% detrital microcline and up to 10% lithic fragments. These features distinguish the Timiskaming assemblage metasedimentary rocks from the Tisdale assemblage described above. Detrital microcline indicates erosion of potassium feldspar-bearing rocks such as syenite and alkalic metavolcanic rocks and is a common feature in the Timiskaming assemblage (Berger 2002). Quartz-feldspar porphyry, intermediate and mafic tuffaceous rocks form discontinuous units interbedded with the metasedimentary rocks. The depositional environment appears to be transitional from alluvial-fluvial to deep basin turbidites.

Only 2 samples of metasedimentary rocks from Cairo Township were geochemically analysed and results most closely resemble the alkalic metavolcanic rocks described below (*see* Tables 4 and 5, in Appendix). This is reasonable to expect given the abundance of alkalic detritus in the rocks (described above).

## ALKALIC METAVOLCANIC ROCKS

Alkalic metavolcanic rocks and related subvolcanic intrusive rocks underlie parts of Holmes and Flavelle townships east of the Cairo stock. Trachyte flow breccia, mafic and intermediate alkalic flows are intercalated with Timiskaming metasedimentary rocks in Eby and Otto townships.

The metavolcanic rocks in Holmes and Flavelle townships are composed of mafic, intermediate and felsic flows, pyroclastic and epiclastic tuff, lapilli tuff and tuff breccia. Dark green weathering, fine-grained, equigranular mafic flows and derived schist is exposed along the Holmes Lake road east of Holmes Lake. Sparse to abundant fine-grained, green biotite serves to distinguish this rock as alkalic in the field. These flows also contain epidote in the groundmass and in veins; hematite rarely occurs along fractures.

Heterolithic, intermediate and felsic lapilli tuff and tuff breccia are most common (Photo 5). These rocks are pale green to grey weathering and are characterized by clasts that contain black to dark green amphibole phenocrysts in a feldspathic groundmass. Epidote commonly replaces the amphibole and occurs in veins and is disseminated throughout the matrix. Subangular to subrounded metavolcanic clasts are most common and generally do not exceed 25 cm in size; however, quartz vein clasts, aphanitic felsic fragments and rare sulphide mineral clasts were observed. In many places fragments within fragments were observed and this indicates that complex, multi-stage volcanic eruptions and redeposition of material occurred.

The coarsest deposits are centred along the south side of Galer Lake where they form massive, unsorted units. Farther north and east the units generally contain smaller average clast sizes, slightly higher proportion of felsic metavolcanic clasts and are massive to thickly bedded. Lapilli tuff and tuff units on the northeast shores of Galer and Tully lakes are gradational along strike with syenite boulder conglomerate correlated with the Timiskaming assemblage (see above).

Fine- to medium-grained, massive andesite to trachyandesite covers approximately 3 km$^2$ centered at Dixon Lake. This rock is pink to chalky white weathering, contains dark green, euhedral amphibole phenocrysts up to 5 mm in size and locally contains euhedral perthite crystals up to 1 cm in size. Moore (1966) referred to this rock as hornblende syenite and suggested that it was related to other syenite intrusions in the area (i.e., Cairo stock). The trachyandesite has gradational contacts with the surrounding metavolcanic rocks and in many places it is difficult to separate the rock types. The trachyandesite locally displays monolithic brecciation interpreted by the author to represent hydraulic fracturing in the upper level of a magma chamber. Further, the geochemistry of the trachyandesite is similar to the surrounding metavolcanic rocks and unlike the syenite intrusions in the map area (see below). The textures, contact relationships and geochemistry indicate that the trachyandesite is a subvolcanic pluton that intruded its own volcanic pile and for these reasons, the rock is included within the alkalic metavolcanic rocks on the map (in back pocket).

Closely associated with the subvolcanic intrusion are a distinctive suite of feldspar porphyritic dikes. The dikes contain euhedral perthite laths up to 6 cm in size that are elongated parallel to the contacts and that make up from 25 to 50% of the rock. The groundmass is composed of albite, biotite, amphibole and apatite. The rock appears to be a late stage differentiate of the subvolcanic pluton as it is spatially restricted to the pluton and has a similar bulk composition. The dikes, although volumetrically minor, are important because they host gold mineralization at the Loki gold occurrence in Holmes Township.

Alkalic metavolcanic rocks are intercalated with Timiskaming metasedimentary rocks in Eby and Otto townships where they represent the western extension of the main Timiskaming assemblage at Kirkland Lake. Trachyte flow breccia up to 400 m thick occurs at the base of the Timiskaming assemblage south of Kenogami Lake and is similar to flow breccia along the railway track in Grenfell Township described by Ayer et al. (1999). The breccia is composed of rounded to subangular monolithic trachyte fragments up to 30 cm in size in a crystal-rich groundmass with amphibole and perthite crystals up to 2 cm in size. The rocks are strongly hematized and locally strongly sheared. In thin section the hematite is manifest as a fine opaque dusting in the groundmass and as rims around the amphibole phenocrysts. These textures are similar to textures observed in alkali metavolcanic rocks in the

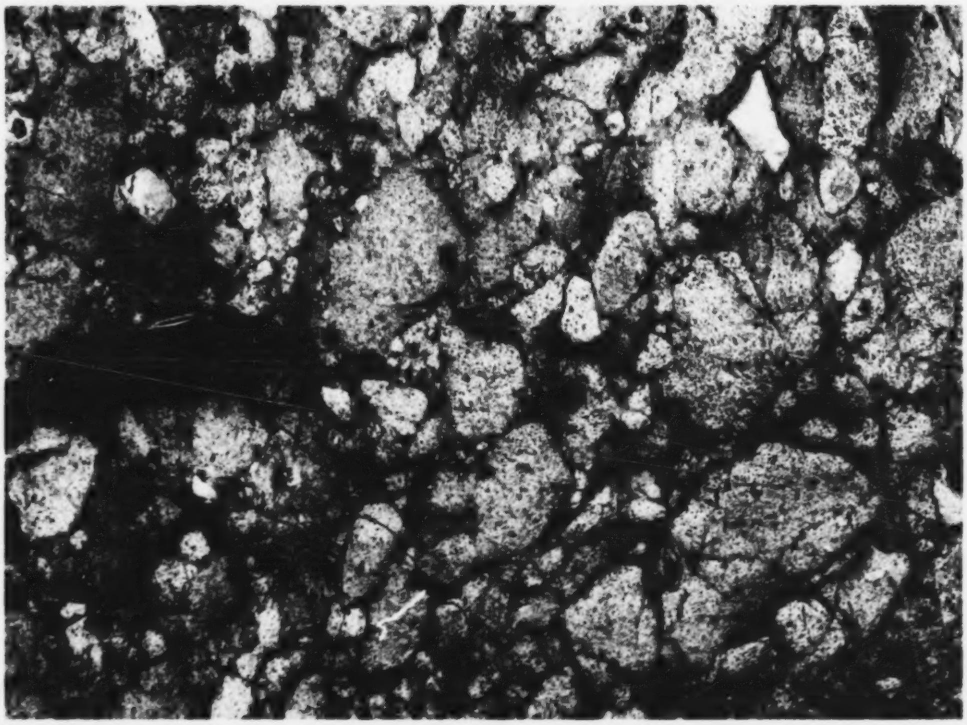


**Photo 5.** Heterolithic intermediate alkalic tuff breccia on the southwest shore of Galer Lake, Holmes Township. Outcrop located at UTM 536983E, 5319083N, NAD 83, zone 17. Knife is 8 cm long.

Shebandowan area west of Thunder Bay that were interpreted to represent subaerial oxidation in an emergent Archean craton (Shegelski 1980). The flow breccia unit is unconformably overlain by conglomerate and trough cross-bedded sandstone suggesting that the transition from volcanism to sedimentation was abrupt in this part of the assemblage. Strongly hematized and sericitized rocks occur as narrow units (3-10 m wide) elsewhere within the Timiskaming metasedimentary rocks and as the alteration is so intense to obliterate contact relationships and primary textures, they are interpreted to be alkali flows or dikes. An assay of this material did not result in any significant mineralization (Sample 03-BRB-147, Table 11, in Appendix).

Mafic and intermediate alkali flows crop out on the north shore of the Blanche River along the Eby–Grenfell township boundary. These flows are densely amphibole and biotite phenocrystic, commonly amygdaloidal and generally magnetite-bearing. They are interbedded with conglomerate and sandstone and can be traced on airborne magnetic geophysical maps for over 6 km to the northeast (OGS 2000).

Geochemical analyses for alkalic metavolcanic and subvolcanic rocks are presented in Table 5 (in Appendix). Figure 9 shows that most of the sampled rocks have calc-alkalic to shoshonitic geochemical affinities and are similar to some of the alkalic metavolcanic rocks at Kirkland Lake and along Highway 101 east of Matheson (Berger 2002; Collison 1993). There are ultrapotassic and leucite-bearing rocks in the Kirkland Lake area that were not identified in the present map area. Figure 10 shows REE and

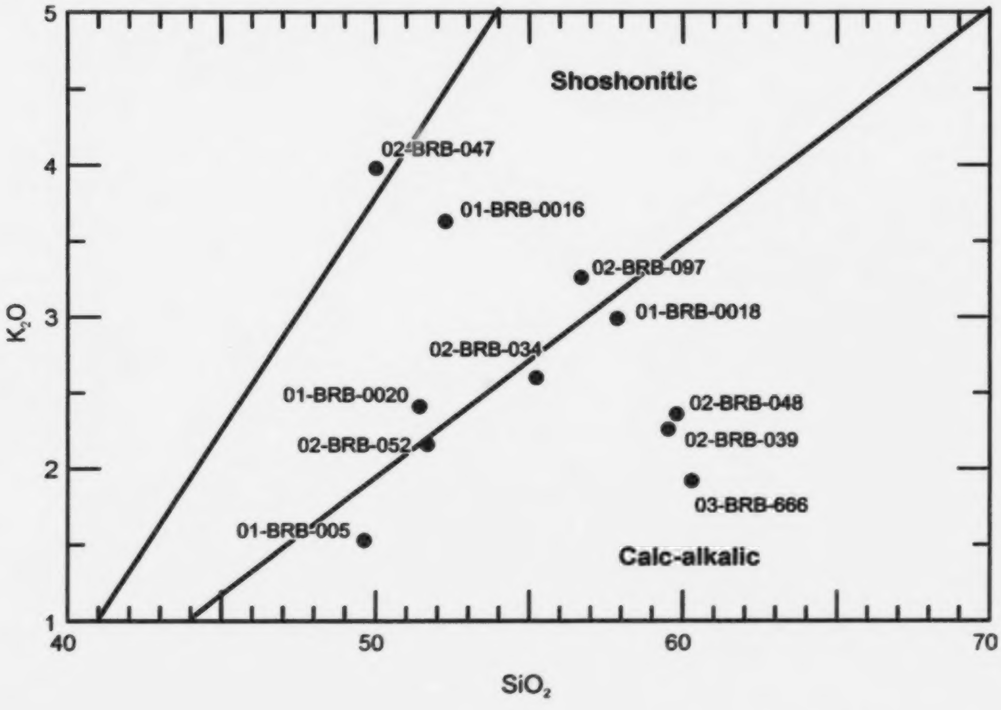


**Figure 9.** Classification of alkalic metavolcanic rocks, Highway 66 area (*after* Wheller et al. 1987).

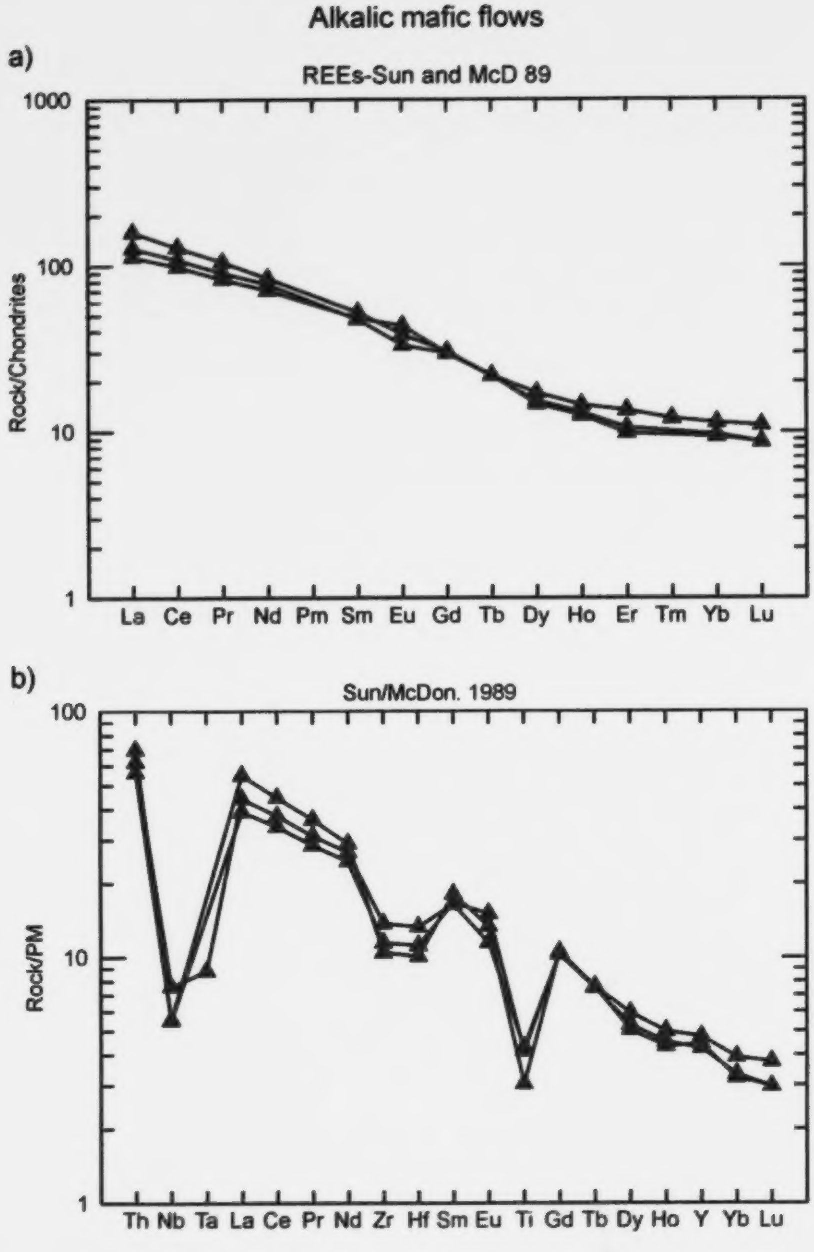


**Figure 10a,b.** Trace element geochemistry for alkalic metavolcanic and subvolcanic rocks, Highway 66 area. Samples selected: 01-BRB-005, 01-BRB-016, 01-BRB-020.

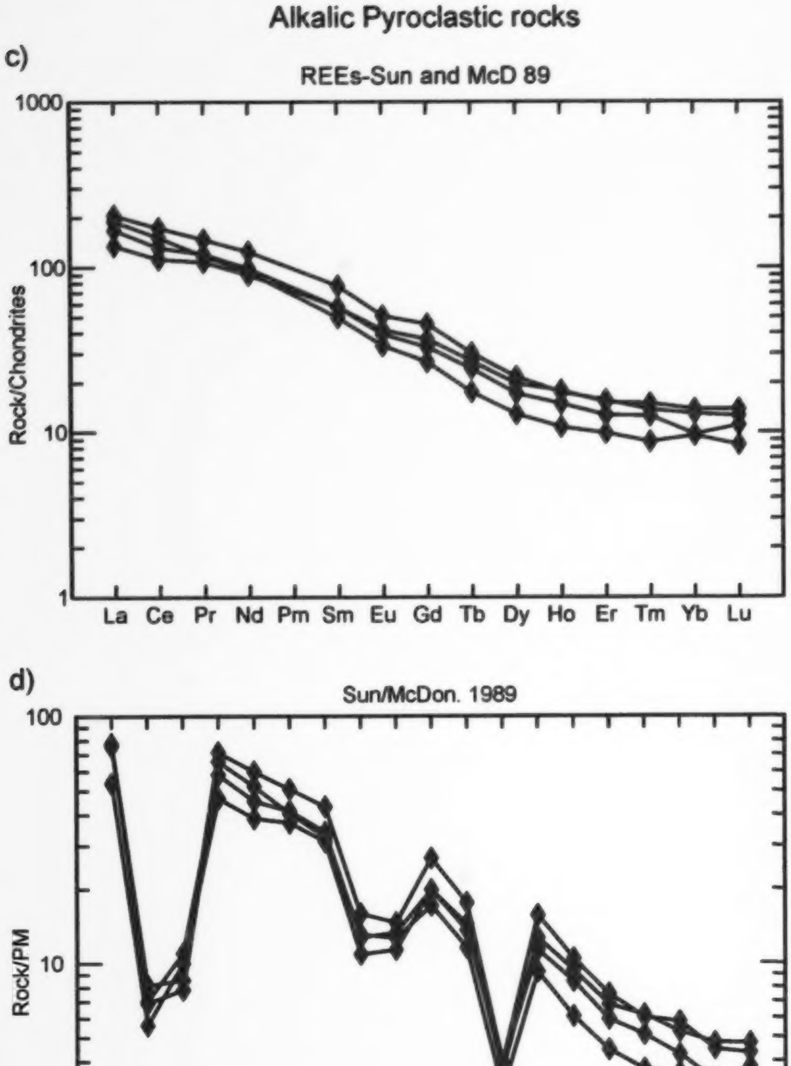


**Figure 10c,d.** Trace element geochemistry for alkalic metavolcanic and subvolcanic rocks, Highway 66 area. Samples selected: 02-BRB-034, 02-BRB-047, 02BRB-052, 02-BRB-097.

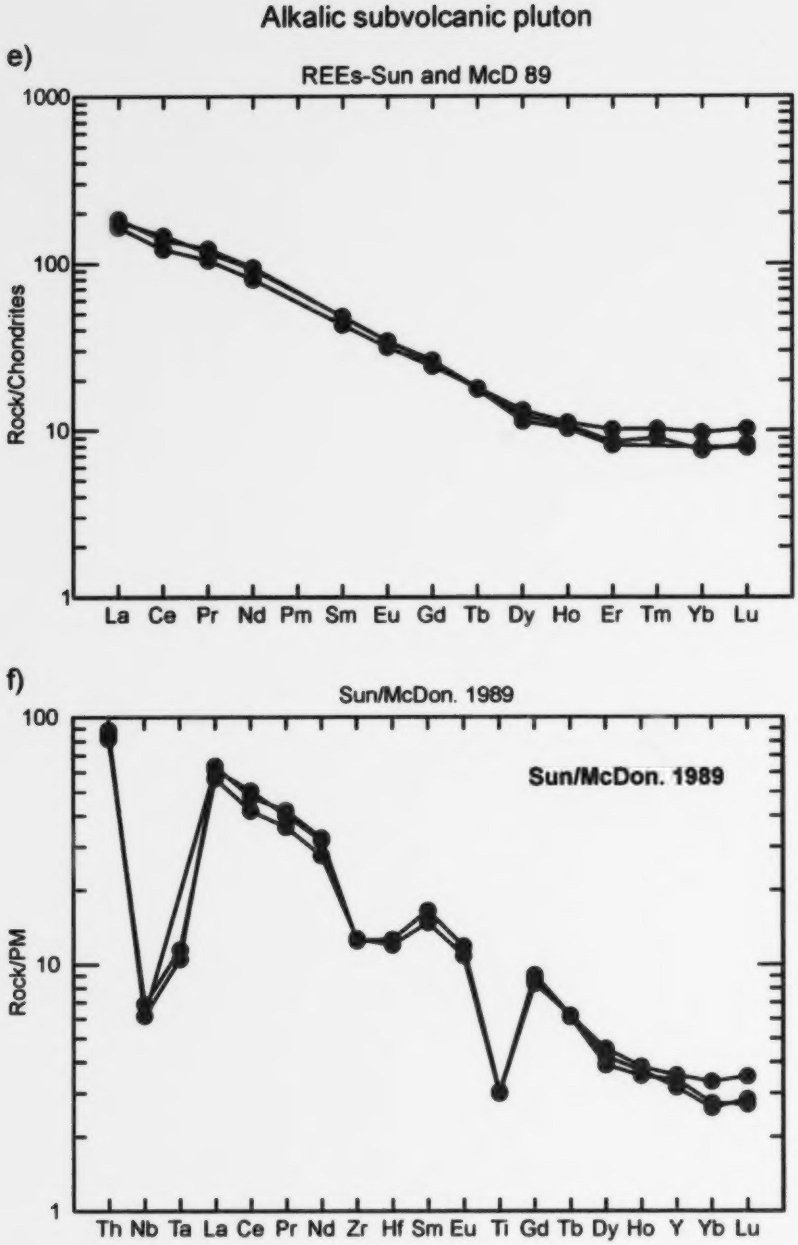


**Figure 10e,f.** Trace element geochemistry for alkalic metavolcanic and subvolcanic rocks, Highway 66 area. Samples selected: 02-BRB-048, 01-BRB-018, 02-BRB-039.

extended element patterns for the various alkalic rocks in Holmes Township. These rocks contain higher LREE and thorium and depleted hafnium and zirconium compared to the calc-alkalic intermediate metavolcanic rocks described above (*see* Figure 7). The strong niobium, tantalum and titanium depletions are compatible with derivation of magma by partial melting in a subduction zone. Geochronological data are not available for the alkalic rocks in Holmes Township but based on flow morphology and geochemistry, they are correlated with the Timiskaming assemblage and indicate that alkaline volcanism extended west of the Kirkland Lake area.

## ULTRAMAFIC AND MAFIC INTRUSIVE ROCKS

Ultramafic and mafic intrusive rocks include peridotite, gabbro, biotite-bearing gabbro, and diorite. A number of intrusions, varying in size from narrow dikes, sills and small plutons to 7 km$^2$, were mapped in the area.

Several ultramafic and mafic sills were mapped in south Cairo Township. A gabbro sill adjacent to the Round Lake batholith extends up to 6 km east from the Montreal River and is up to 400 m wide. Medium-grained, equigranular gabbro is the main rock type; leucogabbro and pegmatitic gabbro are subordinate. The sill is folded and extensively recrystallized, although layering between gabbro and leucogabbro was observed locally. It is texturally similar to the gabbroic intrusion in Eby Township and to the leucogabbro phases of the intrusion in Flavelle Township. A single gabbro sample was selected for geochemistry and shows a tholeiitic trend with low REE abundance and flat trace element patterns (Sample 02-BRB-215, Table 6, Figures 11c, d).

A narrow folded sill composed of peridotite, gabbro and quartz diorite extends from Highway 65 to Moyneur Lake and along the south shore of St. Paul Lake in Cairo Township. Massive peridotite and related schist occurs in the nose of a fold exposed on Highway 65 and is characterized by development of blue-green serpentine and narrow asbestos veins. Peridotite is also exposed near the Matachewan town dump and along the old highway road bed to the southwest. The peridotite is massive with abundant serpentine and locally displays polyhedral jointing. At the town dump the peridotite is in gradational contact with magnetic gabbro. Medium- to coarse-grained gabbro that locally contains quartz diorite pods comprises the rest of the sill. The gabbro is strongly magnetic which distinguishes it from nearby mafic metavolcanic flows and permits the sill to be traced on airborne magnetic geophysical maps (OGS 2000). Local disseminated chalcopyrite comprises up to 5% of the gabbro and an assay of this material returned 1288 ppm Cu (Sample 02-GL-234, Table 11). Geochemistry for selected samples of this sill is presented in Tables 1 and 6, Figures 11 c, d. The high iron tholeiitic REE and extended element patterns are similar to nearby basaltic rocks and it is possible that the sill represents a feeder intrusion for the flows.

A gabbroic intrusion covering approximately 7 km$^2$ underlies parts of Flavelle, Holmes, Gross and Burt townships. Strongly magnetic melanogabbro crops out along the Flavelle–Holmes township boundary approximately 250 m north of Highway 66, where it is coarse-grained, equigranular and massive. The dark green to black weathering rock contains abundant amphibole, epidote and magnetite with only minor plagioclase. The melanogabbro is gradational with gabbro and diorite along Highway 66, where amphibole and plagioclase are approximately in equal proportions. Several outcrops in a logged over area in northeast Flavelle Township show gabbro, leucogabbro, and pegmatitic gabbro phases occurring together. Locally layering was observed and near the south contact, gabbro and basalt and intermediate tuff are intermixed, suggesting that the gabbro is synvolcanic with the mafic metavolcanic flows. Medium-grained quartz diorite with up to 20% quartz occurs in the north part of the intrusion. This rock was included in the mafic intrusion based on general field characteristics, such as grain size,

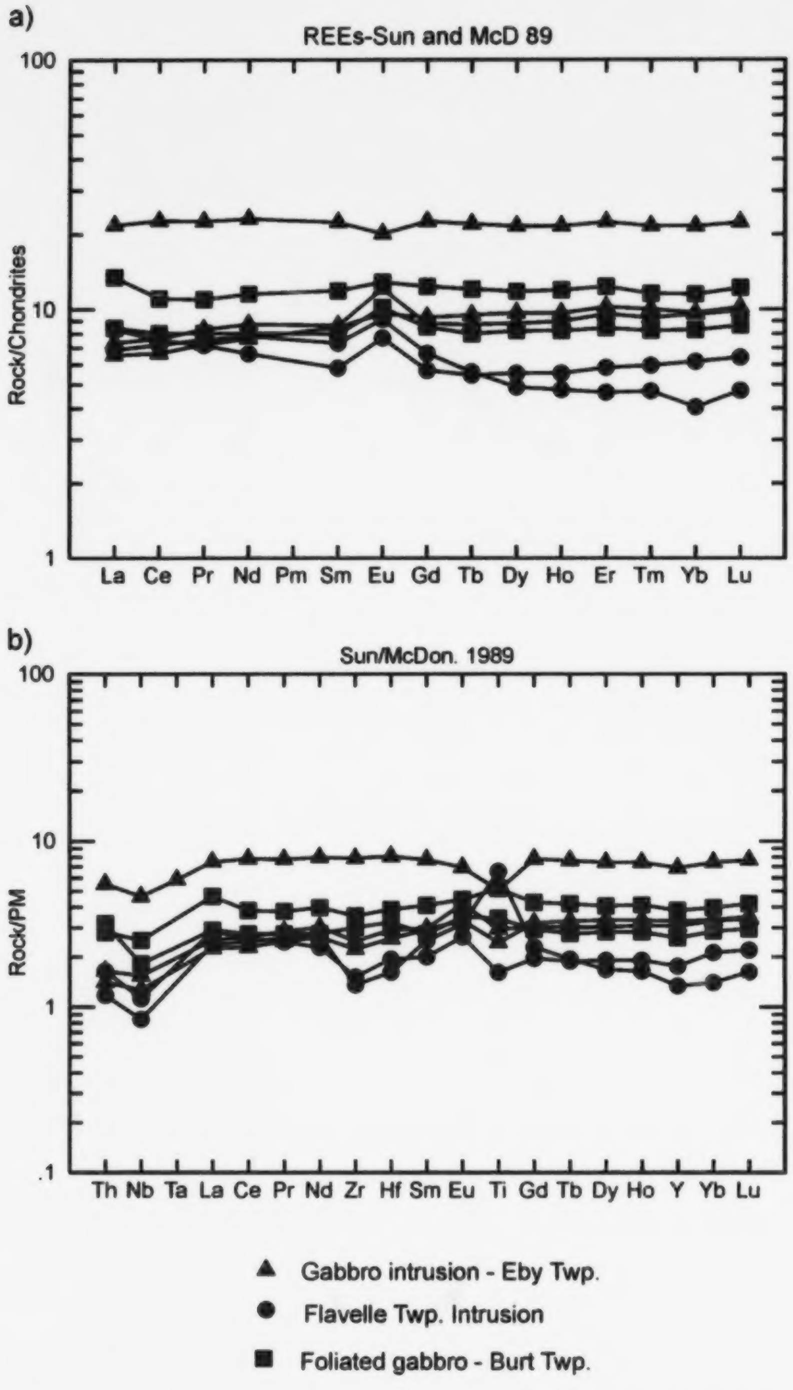


**Figure 11a,b.** Trace element geochemistry for mafic intrusive rocks, Highway 66 area.

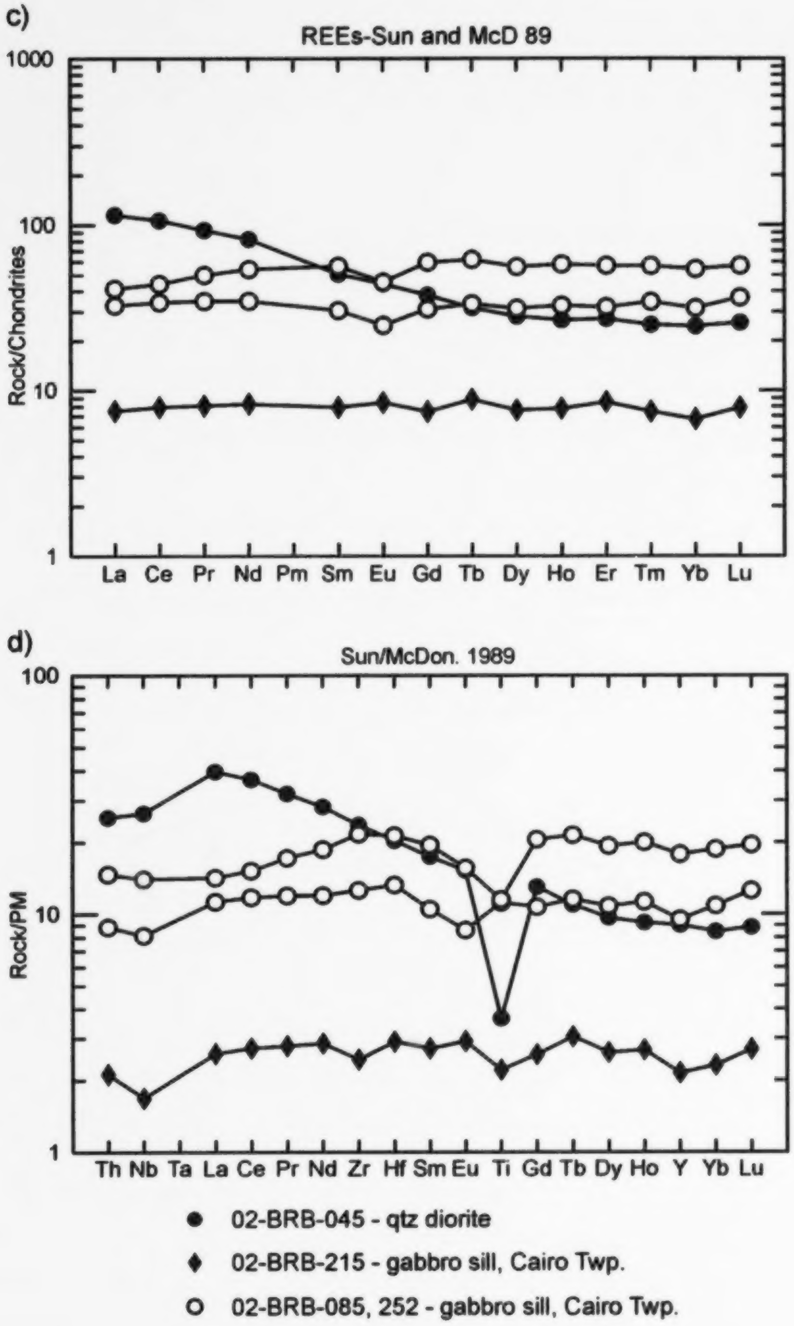


**Figure 11c,d.** Trace element geochemistry for mafic intrusive rocks, Highway 66 area.

proximity to the melanogabbro, and similarity to the leucogabbro phase of the intrusion. However, this part of the map area has poor outcrop exposure and the author is uncertain of the field relationships.

Geochemistry for the gabbroic phases of the intrusion is slightly different than other gabbroic rocks in the area (Table 6, Figure 11a, b). The REE patterns have a negative slope with a positive europium anomaly indicative of cumulate plagioclase in the rocks. The quartz diorite phase is more strongly fractionated (negative REE slope) and may not be related to the gabbroic rocks (Figure 11c, d).

A gabbroic intrusion occurs around the periphery of quartz monzonite and syenite in northwest Burt and central Holmes townships. This gabbro is medium- to coarse-grained, equigranular, strongly recrystallized and foliated. Field relationships are uncertain due to poor exposure but the gabbro is cut by syenitic dikes, feldspathic stringers and is commonly hematized. It is older than the felsic plutonic rocks but the geochemistry indicates that the gabbro is tholeiitic rather than calc-alkalic or alkalic like the nearby felsic intrusions (Tables 6 and 9, Figures 11a, b). The author also infers that the gabbro separates the felsic intrusive rocks in Burt Township from felsic intrusive rocks in Holmes Township based on airborne magnetic geophysical data (OGS 2000). This represents a major change from previous interpretations that have implications for future mineral exploration in the area (Moore 1966, Jensen 1990).

Several ultramafic and mafic intrusions underlie parts of Eby and Otto townships. An isolated outcrop of massive peridotite underlies southwest Otto Township. This strongly magnetic rock contains narrow asbestos stringers; however, the outcrop and associated airborne magnetic geophysical anomaly (OGS 2000) are of limited extent. The lack of outcrop in this area does not permit adequate delineation of the peridotite and the author is uncertain if the rock is truly intrusive or a massive cumulate komatiite flow. A sample of this material was geochemically analysed and data are presented in Table 2 (Sample 03-BRB-189).

Peridotite and gabbro occur together in sills up to 100 m thick exposed along Highway 11 in Eby Township. These rocks are equigranular and massive and are interlayered with fine-grained rusty chert and mafic metavolcanic rocks. Narrow chilled margins occur on the sills but contact thermal effects in the host rocks are minimal. The limited aerial extent of the sills suggests that they are part of the stratigraphy, possibly subvolcanic feeders to nearby basaltic flows.

A gabbroic intrusion covering approximately 5.5 km$^2$ underlies northwest Eby Township. This intrusion is composed of gabbro, leucogabbro, quartz gabbro and diorite. The rocks are uniformly medium-grained, green to dark green weathering and weakly to strongly foliated. The contact with surrounding metavolcanic rocks is commonly sharp and in many places marked by narrow faults or shear zones. The intrusion is strongly recrystallized, with secondary amphibole and sausauritized plagioclase most common. A relict sub-ophitic to ophitic texture is locally preserved. Geochemistry (Table 6, Figure 11a, b) indicates that the intrusion is tholeiitic with cumulate and evolved phases. The evolved phase corresponds to quartz gabbro and is geochemically similar to the surrounding iron tholeiite basalts. The Eby intrusion likely represents a subvolcanic magma chamber.

## INTERMEDIATE AND FELSIC INTRUSIVE ROCKS

### Cairo Stock

The Cairo stock is an oval alkalic intrusion that covers approximately 72 km$^2$ in Cairo, Alma and Holmes townships. The intrusion is composed almost entirely of medium-grained, equigranular syenite with minor quartz syenite that varies in colour from pink to red to deep earthy red. Black amphibole is the principal mafic mineral and commonly comprises less than 10% of the rock but may reach up to 30% near the margins. Biotite is rare and confined to rocks near the margins of the pluton. In thin section, perthite is the major mineral constituent, with common green pleochroic amphibole. Titanite, apatite, quartz and magnetite are common accessory minerals and locally may comprise up to 5% of the rock. Hematite alteration is pervasive and is manifest as rims around magnetite and mafic minerals and as fine dustings throughout the rock. In some thin sections perthite is rimmed by clear albite and green amphibole is rimmed by blue-green amphibole indicative of late stage sodic alteration.

The Cairo stock is geochemically homogenous with elevated LREE and pronounced negative niobium, tantalum and titanium anomalies (Table 7, Figure 12a, b). The typical syenite contains greater LREE and does not have the negative hafnium and zirconium anomalies that are observed in the alkalic metavolcanic rocks (*see* Figure 10). These data preclude the Cairo stock as the origin of the alkalic metavolcanic rocks in Holmes Township. The syenite is geochemically similar to alkali feldspar syenite at the Iris intrusion in Harker Township approximately 78 km to the northeast (Pigeon 2003; Berger 2002). Figures 12c and d show geochemical patterns for atypical rocks from the Cairo stock. Sample JAA-00-263 is a sheared syenite that shows depleted LREE compared to typical syenite. A possible explanation is that fluids moved through the sheared rock and stripped the LREE from the syenite. Sample JAA-00-258 has a "U"-shaped REE pattern with low total REE, low barium, low potassium and a pronounced positive hafnium and zirconium anomaly (Figure 12c, d, Table 7). The sample is altered with respect to typical syenite and the geochemical patterns are similar to those observed in altered and gold-mineralized alkalic rocks along the Porcupine–Destor fault zone (Berger 2002). This indicates that portions of the Cairo stock are prospective targets for gold mineralization.

White weathering, fine- to medium-grained albitite crops out along the west shore of Tully Lake and in stripped outcrop in the Galer fault approximately 1 km to the southwest in Holmes Township. This rock, which is composed of perthite, albite, sericite and magnetite, is unusual for a number of reasons. The grain size and crystal habit of the albite indicates that the rock is intrusive but the field appearance is similar to rhyolite. Trace element geochemistry is similar to F-II rhyolite but there is pronounced niobium and titanium depletions similar to the syenite (cf. Lesher et al. 1986; Table 7, Figure 12c, d). The restricted occurrence of this rock type to fault zones and the eastern contact of the Cairo stock suggest that the rock type results from alteration and differentiation of the alkalic magma.

Several subparallel shear zones transect the Cairo stock. Sheared syenitic rocks are strongly fissile in the deformation zones and show well-developed shear fabrics (*see* "Structure and Metamorphism" below). In thin section, sheared syenite displays mylonite textures such as progressive recrystallization, cataclasis and reduction of grain size from less sheared to more strongly sheared rock (cf. Hobbs, Means and Williams 1976). Such textures indicate that deformation occurred in the brittle-ductile transition zone (cf. Colvine et al. 1988).

The Cairo stock has abrupt contacts with the surrounding host rocks. The south contact is obscured within the Larder Lake–Cadillac deformation zone and is best observed along Highway 66 in Cairo Township. The west and north contacts are abrupt with metasedimentary and metavolcanic rocks. A contact strain aureole was not detected but a hornfelsic contact thermal aureole extends up to 500 m into the host rocks and is characterized by fine matted dark green amphibole in the metavolcanic rocks and strongly recrystallized metasedimentary rocks. The eastern contact with the alkalic metavolcanic rocks is defined by a narrow zone that contains weakly developed gneissic textures and numerous xenoliths.

A sample of sheared syenite was collected for geochronology within the Larder Lake–Cadillac deformation zone in order to provide an absolute age for the Cairo stock and to better constrain the relative age of deformation in the area. Zircons collected from the sample show a crystallization age of 2676 ± 1.7 Ma for the syenite with older inherited zircon ages of 2689 and 2720 Ma (Figure 13). This

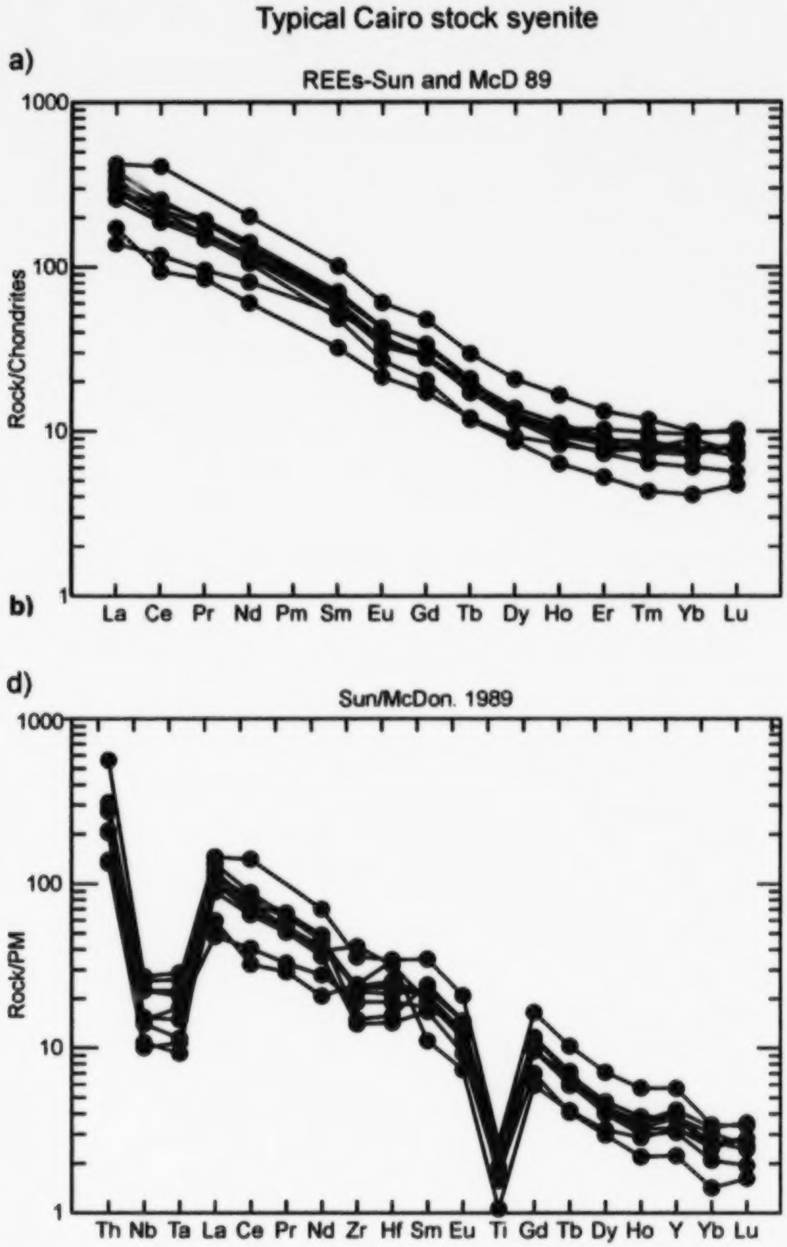


**Figure 12a,b.** Trace element geochemistry for the Cairo stock, Highway 66 area.

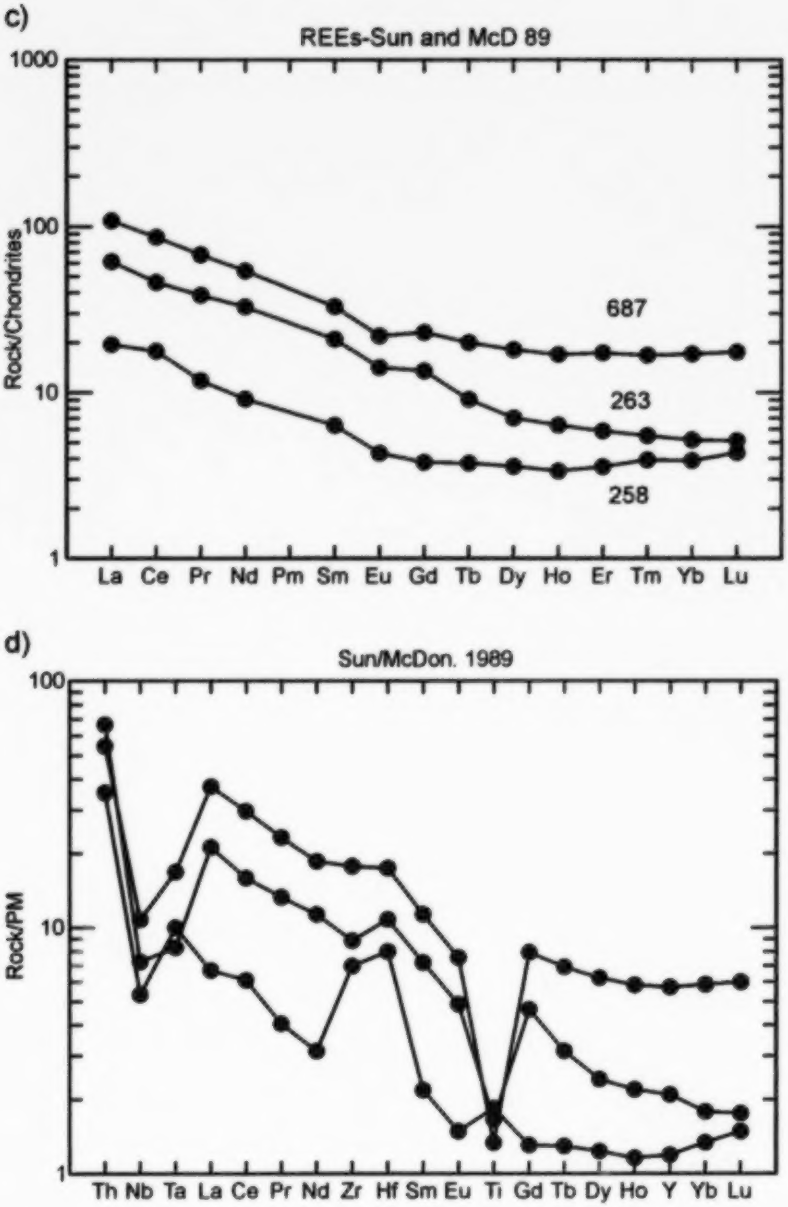


**Figure 12c,d.** Trace element geochemistry for the Cairo stock, Highway 66 area. Samples 03-BRB-687, JAA-00-258, 263.

date is similar to ages for other alkalic intrusive rocks at Kirkland Lake and indicates that the Cairo stock is part of the Timiskaming assemblage (cf. Ayer et al. 2002; Wilkinson, Cruden and Krogh 1999). Further, the date constrains the deformation associated with development of the Larder Lake–Cadillac deformation zone to less than 2676 Ma. Similar age constraints were placed on development of the Porcupine–Destor deformation zone, a parallel regional structure in the Timmins to Quebec area (Berger 2002).

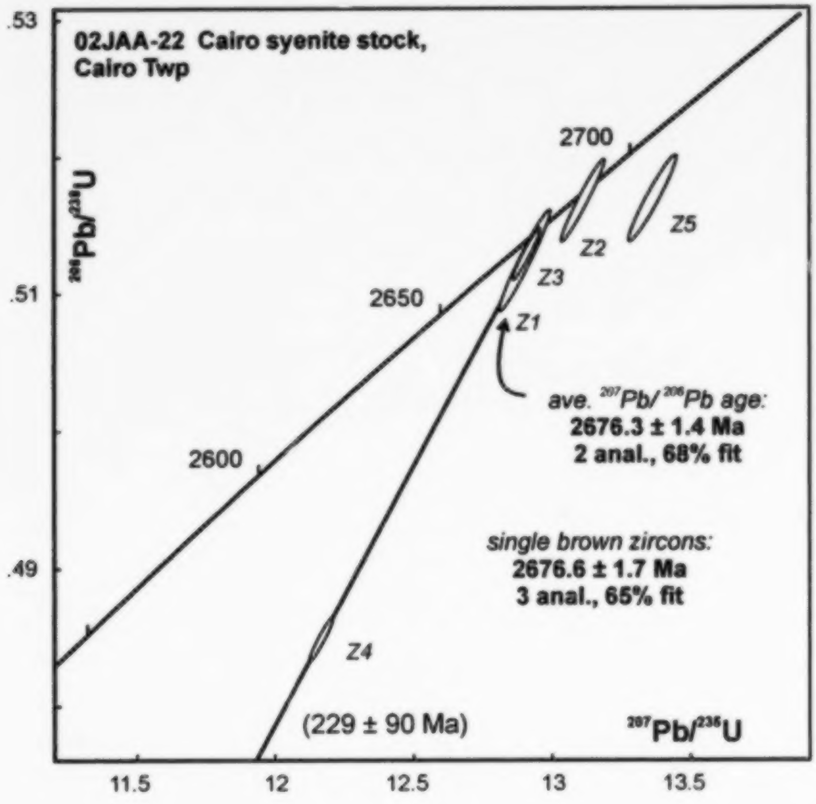


**Figure 13.** Geochronology for Cairo stock, Highway 66 area.

## Otto Stock

The Otto stock is a multiphase, circular, alkalic intrusion covering approximately 100 km$^2$ in Otto and Eby townships. A U-Pb age of 2680 ± 1 Ma was obtained from zircon from syenite in the east part of the intrusion (Corfu et al. 1989). The intrusion is bisected by the Amikougami fault, a major north-striking structure, which not only sinistrally offsets the intrusion but also appears to exert control on the various rock types. For descriptive purposes only, the author refers to that part of the Otto stock east of the Amikougami fault as the "eastern lobe" and that part of the Otto stock west of the fault as the "western lobe".

Syenite is the major rock type in the intrusion and a number of textural variations were recognized. Medium-grained, equigranular syenite is most common and is pink to red weathering with euhedral albite, microcline and perthite crystals that commonly display concentric zonation. Green pleochroic amphibole and rare clinopyroxene are the essential mafic minerals in the syenite. Apatite, titanite, biotite, andradite garnet and zircon are common accessory minerals. Mafic minerals commonly comprise less than 10% of the rock although considerable variation from 5 to 25% was observed. In many places alignment of feldspar laths and mafic minerals defines a foliation interpreted to be primary. Where equant and lath-shaped feldspar up to 3 cm in size occurs in a medium-grained groundmass the term porphyritic syenite or feldspar porphyry is used. Aplitic syenite is a fine-grained, sugary textured rock that occurs as a minor phase of the Otto stock and as dikes that cut the mafic phases of the stock and the country rock. Aplite is generally devoid of mafic minerals and is interpreted as a late phase of the stock. Coarse-grained to pegmatitic syenite underlies a significant portion of the northern and western parts of the intrusion. This rock generally contains crystals in excess of 1 cm in size and commonly contains less than 10% mafic minerals. Megacrystic syenite refers to a rock that contains large feldspar phenocrysts from 2 to 6 cm in size set in a mafic groundmass composed of biotite, clinopyroxene and amphibole (Photo 6). The rock type is confined to the margins of the Otto stock and the feldspar is commonly aligned parallel to the intrusion's contacts.

Discontinuous lenses of mafic minerals commonly form bands aligned with the feldspar, and these lenses resemble lamprophyre as described below. Magnetite is a common accessory mineral and airborne geophysical magnetic anomalies around the periphery of the western lobe correspond to this rock type (OGS 2000).

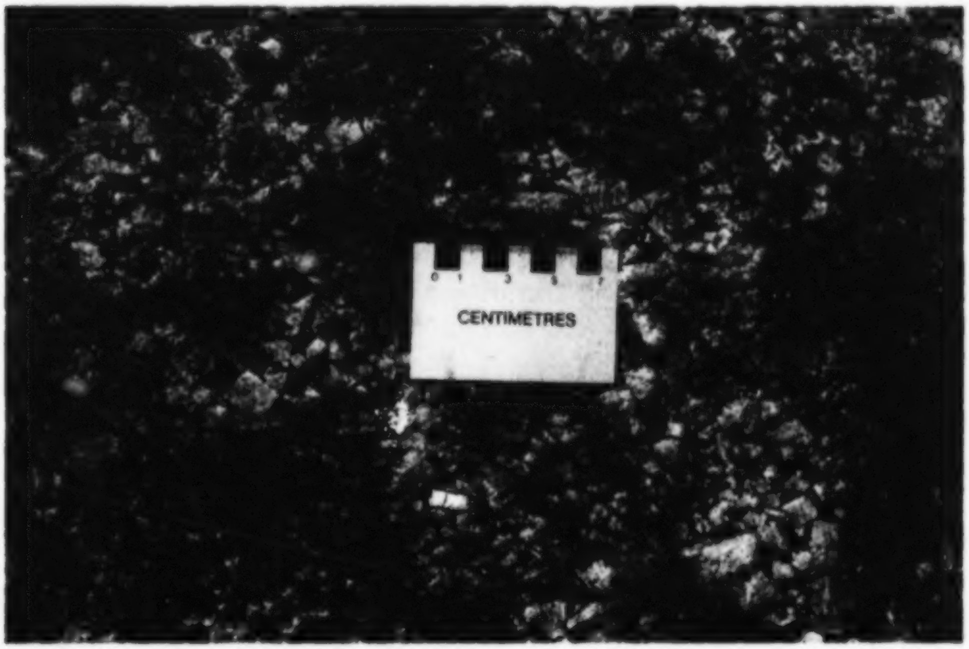


**Photo 6.** Megacrystic syenite from the Otto stock. Large perthite crystals set in an amphibole-clinopyroxene-biotite groundmass. Outcrop in southwest Eby Township, UTM 563869E, 5318813N, NAD 83, zone 17.

"Spotted" syenite is a field term used to describe medium-grained syenite that contains from 1 to 25% rounded mafic inclusions from 1 to 30 cm in diameter (Photo 7). This rock type is found mostly in the eastern lobe of the intrusion but was also observed in a few isolated places west of the Amikougami fault. The inclusions generally display a pronounced internal structure that includes an amorphous ultramafic core composed of talc, magnetite and carbonate. The core may be surrounded by fibrous amphibole (actinolite?) and there is always a biotite rim adjacent to the syenite (*see* Photo 7b). The origin of these inclusions is uncertain but it appears that the syenite entrained ultramafic magma during its emplacement and the ultramafic liquid cooled in situ and reacted with the syenite. There are ultramafic phases of the Otto stock described below that may have supplied the magma for these inclusions. The inclusions have similar morphology to inclusions in alkalic rocks described by Sage (1998a and 1998b) and Vaillancourt, Wilson and Dessureau (2003) in the Wawa area. The rocks at Wawa are known to contain diamonds and this implies that rocks of the Otto stock may also contain diamonds.

Mesocratic syenite is relatively uncommon in the Otto stock and is used to describe syenite that is composed of approximately equal amounts of feldspar and mafic minerals. This rock type occurs near the contacts of the intrusion or as small satellite dikes or intrusions in the country rock. The author infers that contamination with the host rocks is responsible for the formation of the rock.

Syenite gneiss is closely associated with mesocratic syenite and is most common along the north contact of the western lobe of the stock. Gneiss is fine- to medium-grained and composed of strongly foliated to banded feldspar, amphibole biotite and white mica. Well-defined foliation and gneissosity occurs parallel to the contact of the stock. Commonly schlieren of mafic wall rock, alkali gabbro and rarely alkali clinopyroxenite are included in the gneiss. The development of gneiss suggests high temperatures and high strain accompanied intrusion of the western lobe of the Otto stock.

Quartz syenite and alkalic granite occur almost exclusively west of the Amikougami fault in the central part of the western lobe. This rock type is light pink to pink weathering and is very similar to syenite except that rounded quartz "eyes" comprise up to 20% of the rock. Microcline, perthite and albite are common and mafic minerals, mainly aegirine-augite, comprise less than 15% of the rock (Sutcliffe et al. 1990).

Mafic and rare ultramafic alkali intrusive rocks occupy the central part of the western lobe and occur along the northeast contact of the eastern lobe of the stock. Smith and Sutcliffe (1988) first recognized these rocks as intrusive phases of the stock and this report expands and clarifies some of their observations. A narrow unit (up to 500 m wide) of melasyenite, alkali gabbro and hornblendite occurs along the northeast contact of the eastern lobe. These rocks are dark grey to black weathering and are generally equigranular to locally feldspar porphyritic. A well-developed igneous foliation and compositional banding is developed parallel to the contact with the host rocks and locally syenite aplite dikes and sills are intruded into the mafic rocks. In thin section, clinopyroxene is most abundant with microcline, perthite and subordinate dark green to blue green amphibole. Apatite, titanite, magnetite and rare andradite garnet are accessory minerals. Nepheline is locally abundant. Apatite may comprise up to 5% of the rock. The mineralogy, textures and field relationships indicate that these are mafic intrusive rocks rather than assimilated supracrustal rocks as suggested by Lawton (1954). The mafic and ultramafic phases are consistently intruded by syenite and aplite dikes, which indicate that these phases are older than the felsic rocks and not younger as Smith and Sutcliffe (1988) inferred.

Pyroxenite-hornblendite forms a narrow unit at the northwest contact of the western lobe in Eby Township. This black weathering, medium- to coarse-grained rock is exposed along Highway 11 where it is cut by numerous syenite and aplite dikes. The rock is composed of clinopyroxene, brown biotite and amphibole with minor microcline (Photo 8). Apatite, titanite and magnetite are common accessory

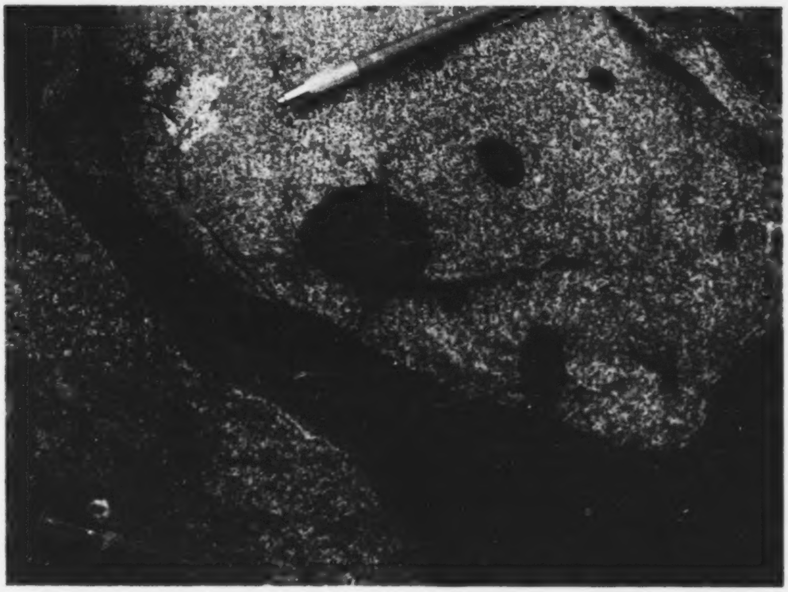


**Photo 7a**. "Spotted" syenite consists of rounded mafic autolith inclusions from 1 to 30 cm in medium-grained syenite. This rock type is found principally east of the Amikougami fault and in only a few places west of the fault. Outcrop located on Rosegrove Road, Otto Township. UTM 570622E, 5320464N, NAD 83, zone 17. Pencil is approximately 15 cm long.

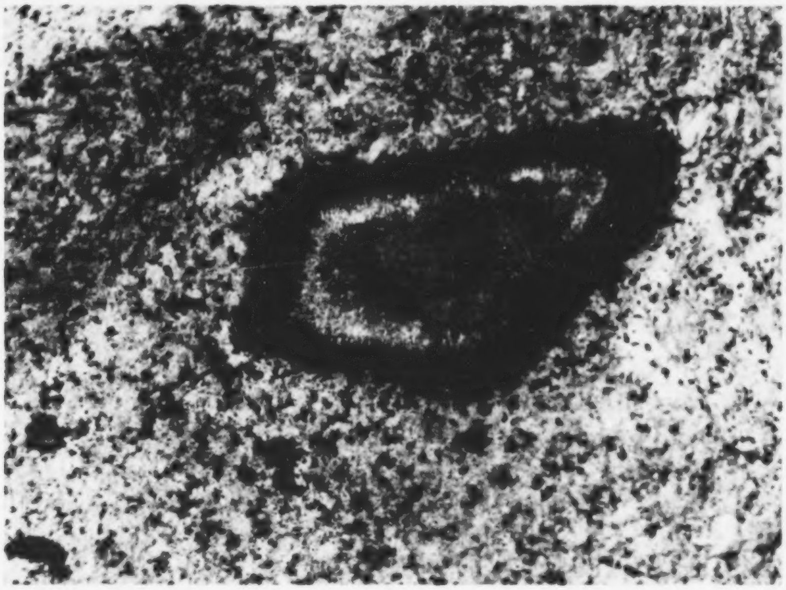


**Photo 7b.** Close up of autolith reveals internal structure that has an amorphous ultramafic core with radial, fibrous amphibole and a biotite rim. These inclusions may be entrained ultramafic magma that reacted with the syenite during cooling. Outcrop located on Highway 112, UTM 573271E, 5322216N, NAD 83, zone 17. Autolith is 6 cm long.

minerals. This rock is equigranular, relatively massive and only weakly deformed and metamorphosed. Copper, gold, platinum and palladium mineralization is associated with the pyroxenite and is discussed below (*see* "Mineralization").

A mafic-ultramafic intrusion covering approximately 2.5 km$^2$ along Highway 11 in south Otto Township is composed of alkali gabbro, hornblendite and lamprophyre. Alkali gabbro is the most common rock type and is composed of clinopyroxene, amphibole and microcline with up to 20% biotite locally. Apatite, magnetite and titanite are common accessory minerals. The rock is medium-grained, equigranular with up to 25% xenoliths and mafic autoliths from 5 mm to 30 cm in size. Some autoliths display zonation similar to those described in Photo 7b; others, especially the smaller ones, have only a biotite rim with no fibrous amphibole. In thin section, the cores of these smaller autoliths are composed of talc and magnetite intergrowths or anhedral pyroxene and potassium feldspar. Biotite occurs in 2 petrographically distinct habits in the alkali gabbro. Green to dark green, anhedral biotite occurs as individual crystals or as cores to brown euhedral biotite crystals which are more common. The brown biotite is inferred to crystallize after the green biotite, which is inferred to reflect evolution of the oxidation state of the magma over time (Lalonde 1992). Xenoliths composed of gneiss, mafic metavolcanic rocks, rare sulphide mineral fragments and ultramafic nodules occur throughout the intrusion but are most common near the north contact with alkali granite.

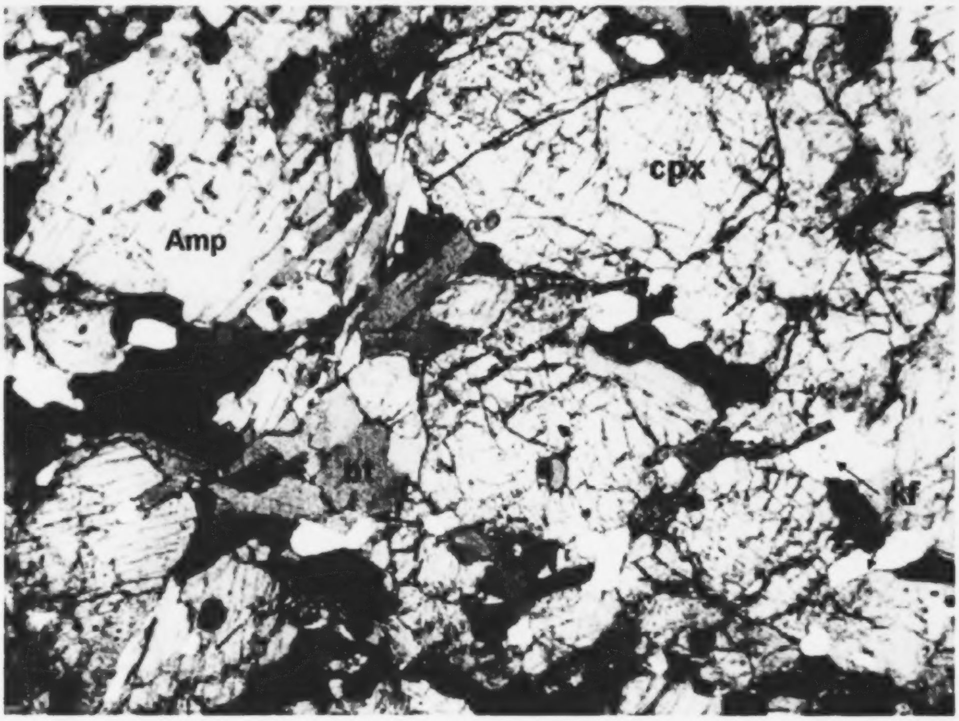


**Photo 8.** Photomicrograph of alkali pyroxenite from outcrop on Highway 11, Eby Township. Clinopyroxenite (cpx) and biotite (bt) are the most abundant minerals with minor amphibole (amp) and potassium feldspar (kf). This rock hosts copper-gold-PGE mineralization. Plane polarized light; field of view approximately 4 mm. UTM 563377E, 5323812N, NAD 83, zone 17.

minerals. This rock is equigranular, relatively massive and only weakly deformed and metamorphosed. Copper, gold, platinum and palladium mineralization is associated with the pyroxenite and is discussed below (*see* "Mineralization").

A mafic-ultramafic intrusion covering approximately 2.5 km$^2$ along Highway 11 in south Otto Township is composed of alkali gabbro, hornblendite and lamprophyre. Alkali gabbro is the most common rock type and is composed of clinopyroxene, amphibole and microcline with up to 20% biotite locally. Apatite, magnetite and titanite are common accessory minerals. The rock is medium-grained, equigranular with up to 25% xenoliths and mafic autoliths from 5 mm to 30 cm in size. Some autoliths display zonation similar to those described in Photo 7b; others, especially the smaller ones, have only a biotite rim with no fibrous amphibole. In thin section, the cores of these smaller autoliths are composed of talc and magnetite intergrowths or anhedral pyroxene and potassium feldspar. Biotite occurs in 2 petrographically distinct habits in the alkali gabbro. Green to dark green, anhedral biotite occurs as individual crystals or as cores to brown euhedral biotite crystals which are more common. The brown biotite is inferred to crystallize after the green biotite, which is inferred to reflect evolution of the oxidation state of the magma over time (Lalonde 1992). Xenoliths composed of gneiss, mafic metavolcanic rocks, rare sulphide mineral fragments and ultramafic nodules occur throughout the intrusion but are most common near the north contact with alkali granite.

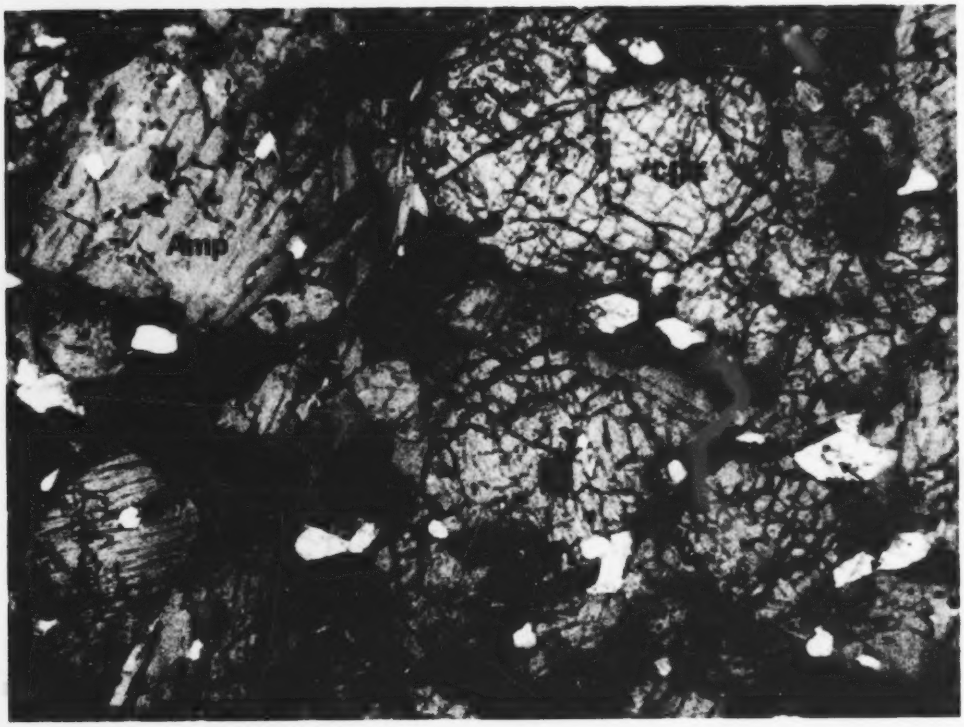


**Photo 8.** Photomicrograph of alkali pyroxenite from outcrop on Highway 11, Eby Township. Clinopyroxenite (cpx) and biotite (bt) are the most abundant minerals with minor amphibole (amp) and potassium feldspar (kf). This rock hosts copper-gold-PGE mineralization. Plane polarized light; field of view approximately 4 mm. UTM 563377E, 5323812N, NAD 83, zone 17.

Hornblendite is composed mostly of euhedral amphibole with lesser amounts of clinopyroxene, biotite and microcline. Apatite, titanite and magnetite are again common accessory minerals. Hornblendite varies from equigranular to porphyritic with large oikocrysts (up to 5 cm in size) of euhedral amphibole crystals enclosing clinopyroxene and biotite. In a few outcrops along Highway 11 oikocrysts "float" in a white microcline-bearing groundmass and have a rather spectacular appearance (Photo 9). This texture appears to be cumulate; however, further study is needed to determine the mineral paragenesis and its petrologic significance. In some outcrops the hornblendite contains ultramafic talc-magnetite nodules which the author interprets to be connate inclusions. This is based on the mapping of an ultramafic unit on the north shore of Round Lake, which is petrographically similar to the nodules and displays alkalic geochemical patterns (see below). The author infers that the mafic-ultramafic intrusion is derived from a more primitive magma, inclusions of which are entrained in the hornblendite.

Lamprophyre is a subordinate rock type that has 2 principal mineral assemblages. A rock type that contains amphibole in greater than or equal amounts of biotite even though the groundmass may contain a significant proportion of microcline is termed lamprophyre for the purposes of this report. This rock type is gradational with alkali gabbro in the mafic-ultramafic intrusion described above and is inferred by the author to be a phase of the Otto stock. This type of lamprophyre also intrudes younger phases of the Otto stock and cuts phases of the Round Lake batholith on Highway 66. Additionally, groundmass in the megacrystic syenite (*see* Photo 6) is similar to the mineralogy of the lamprophyre and commonly forms mafic segregations and bands that resemble the lamprophyre.

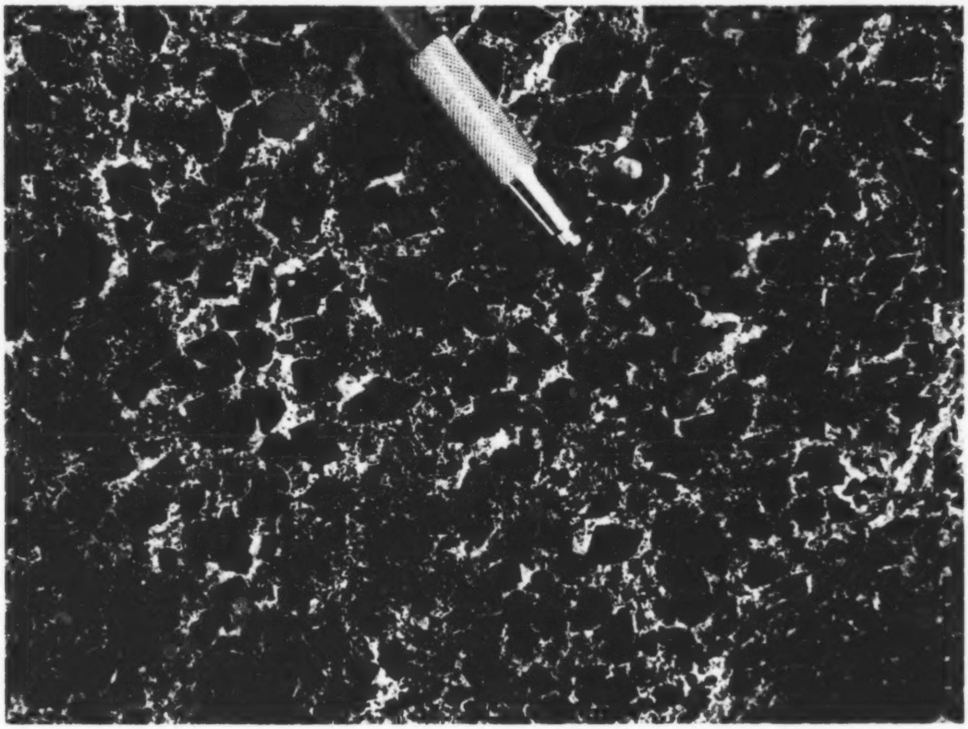


**Photo 9.** Oikocrysts of amphibole rimming biotite and clinoproxene "floating" in a microcline-bearing groundmass in outcrop along Highway 11 in Otto Township. A mafic phase of the alkaline Otto stock. Outcrop located at UTM 566395E, 5320164N, NAD 83, zone 17. Pencil tip is approximately 4 cm long.

Lamprophyre that is composed of equal amounts of biotite and amphibole or that is dominated by biotite occurs as dikes that intrude all Neoarchean rocks in the map area. The origin of these dikes is less certain than the lamprophyre described above and their widespread occurrence indicates that mafic alkalic magma, other than the Otto stock, intruded the map area.

Fragmental lamprophyre is exposed along Highway 11 approximately 500 m north of the Otto stock and in isolated outcrop 800 m along strike in Otto Township. At each location subangular to subrounded mafic fragments up to 15 cm in size occur in a biotite-amphibole-carbonate matrix. Layering and crude clast gradation was observed along Highway 11. Pervasive and vein hematite and epidote alteration are common. Concentrically zoned euhedral amphibole, green and brown pleochroic biotite and rare clinopyroxene are the major mafic minerals observed in thin section. These minerals occur in a fine-grained matrix composed of carbonate, feldspar, brecciated biotite and amphibole crystals. Contacts appear to be abrupt with other units but relationships are obscured by overburden. The lamprophyric rocks may be altered intermediate tuff breccia; however, the zoned amphibole, primary pyroxene and distribution of the rocks suggest that the lamprophyre is intrusive. Fragments, layering and clast gradation can occur by fluidization processes in diatreme intrusions, and the lamprophyre outcrops are interpreted by the author to be part of a diatreme breccia (cf. Lorenz, McBirney and Williams 1970). Feng and Kerrich (1990) indicated that the central part of the Otto stock crystallized at 1 ± 0.5 kbar, which is consistent with shallow crustal level emplacement and suitable for development of diatremes.

Geochemistry for several samples from the Otto stock is presented in Table 8 (in Appendix) and Figure 14. Mafic phases of the stock contain a wide range of total REE but always have a negative sloping REE pattern, and pronounced negative niobium, tantalum, titanium, zirconium and hafnium anomalies that demonstrate their alkalic geochemical affinity (*see* Figure 14a, b). Rocks with the highest total REE content correspond to rocks with high phosphorus ($P_2O_5$) and imply that the rare earths are contained within apatite. Felsic phases members of the Otto stock display elevated LREE and flat HREE with negative niobium, tantalum and titanium anomalies (Figure 14c, d). These results are comparable with geochemistry for the Otto stock provided by Sutcliffe et al. (1990) and support their conclusion that magma was derived from a depleted mantle source enriched in large ion lithophile elements (LILE) shortly before melting. Further, the mafic and ultramafic phases contain much more hydrous minerals like amphibole and biotite than the felsic phases, which also support the contention than older phases of the stock crystallized under higher ${}_pH_2O$ than the younger phases (Sutcliffe et al. 1990).

Two samples of fine-grained, fragment-poor material display similar alkaline geochemistry (JAA-00-202, 03-BRB-628 in Table 9, in Appendix). The geochemistry is also similar to other phases of the Otto stock and the author does not believe that the similarities are caused by hydrothermal alteration. The elevated $P_2O_5$, which is not normally affected by alteration processes, further confirms the alkaline geochemical affinity of these lamprophyric rocks. If the fragmental lamprophyres are part of a diatreme then there exists the potential for diamonds and these rocks should be tested.

## Round Lake Batholith

The Round Lake batholith underlies the south part of the map area and is composed of tonalite, gneissic and migmatitic diorite and tonalite and granodiorite. The tonalitic rocks comprise an older phase of the batholith and the granodiorite comprises the youngest phase (Chown, Harrap and Moukhsil 2002). The tonalite phase is complex and is best described by a transect extending south from the supracrustal rocks in Burt Township through the contact into the batholith in Gross Township. Tonalite and quartz diorite dikes are common within the supracrustal rocks within 500 m of the contact. The dikes are white to grey weathering, equigranular to feldspar porphyritic and generally 30 cm to 1.5 m wide. They were emplaced

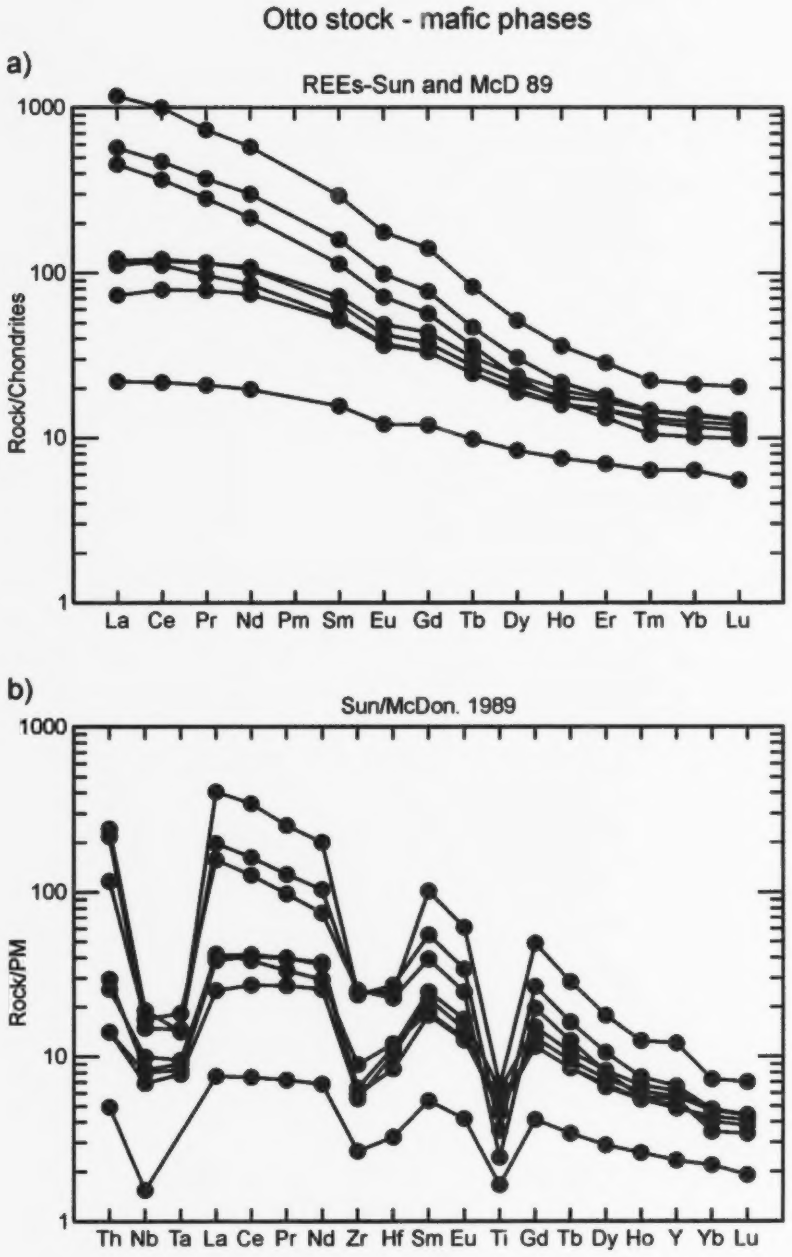


**Figure 14a,b.** Trace element geochemistry for the Otto stock, Highway 66 area.

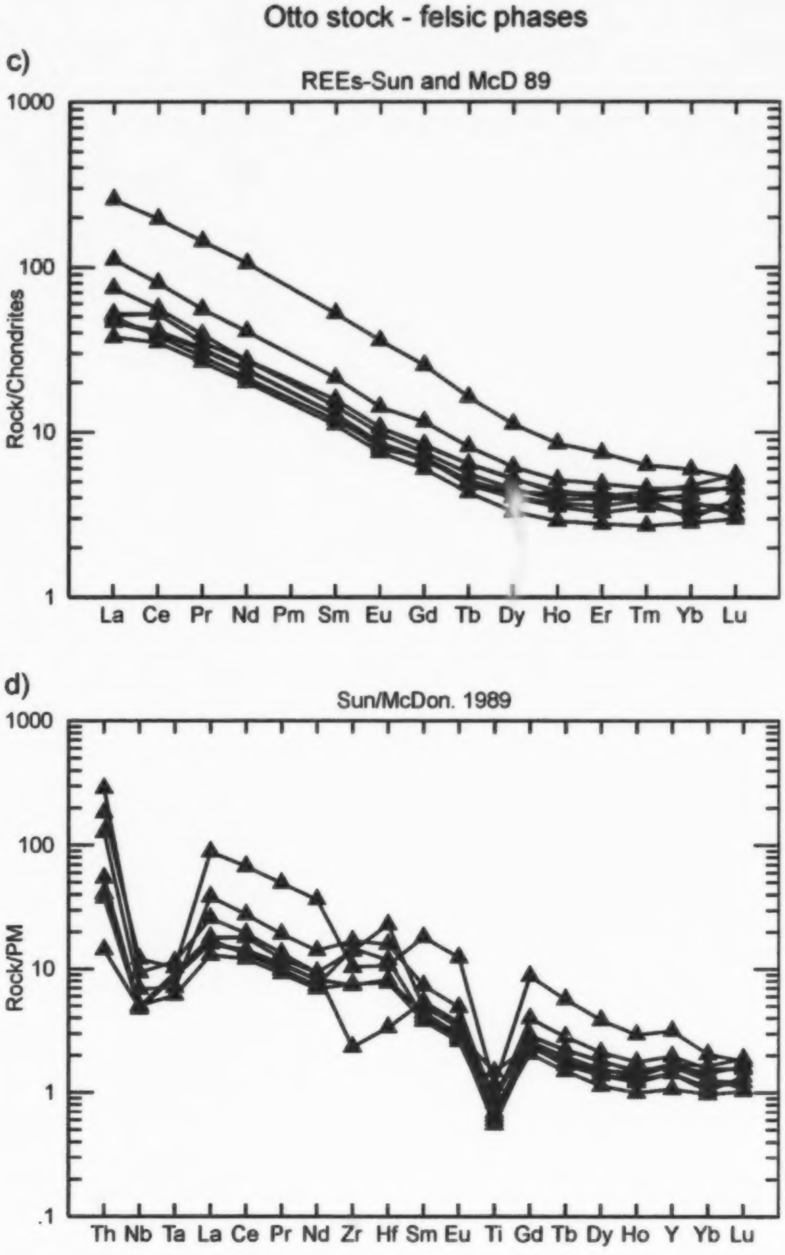


**Figure 14c,d.** Trace element geochemistry for the Otto stock, Highway 66 area.

along foliation planes and in some places display partial melting with the greenstone (i.e., back veining and weak assimilation). The degree of partial melting of the greenstone increases near the contact with the batholith. Agmatite is developed locally with rounded and amoeboid mafic pods in foliated and gneissic diorite. The agmatite is gradational to the south with "in situ" metatexite (Photo 10), where millimetre to centimetre bands of leucosome is rimmed by melanosome (cf. Brown 1973).

The metatexite passes into grey homogeneous diatexite that is intruded by many pink and white tonalite aplite veins in a gravel pit just north of Highway 66. The diatexite extends east along Highway 66 and locally becomes lit-par-lit banded near the eastern contact with the greenstone in Eby Township. Zircons collected from a sample of the lit-par-lit tonalite diatexite returned an U-Pb age of 2743 ± 2 Ma, correlative with the Pacaud assemblage, the oldest metavolcanic package in the southern Abitibi greenstone belt in Ontario (cf. Ayer et al. 2002). Banding, gneissosity and foliation are generally northeast striking parallel to the greenstone contact; local swirls and perturbations in the strike are due to folding in the tonalite. Matachewan diabase and amphibole ± biotite lamprophyre dikes intrude the tonalitic rocks.

The granodiorite phase occurs as a separate intrusion that underlies the southwest part of Eby Township and extends south of the map area. Granodiorite also occurs as a marginal phase adjacent to the supracrustal rocks in Flavelle and Cairo townships and as a satellite intrusion that underlies central Burt Township. The granodiorite is a homogenous, massive, to weakly foliated quartz-rich rock that contains few xenoliths. It is medium-grained, white to pink weathering and rarely quartz porphyritic. Amphibole is the major mafic mineral although chloritized biotite was observed in a few outcrops in Cairo Township.

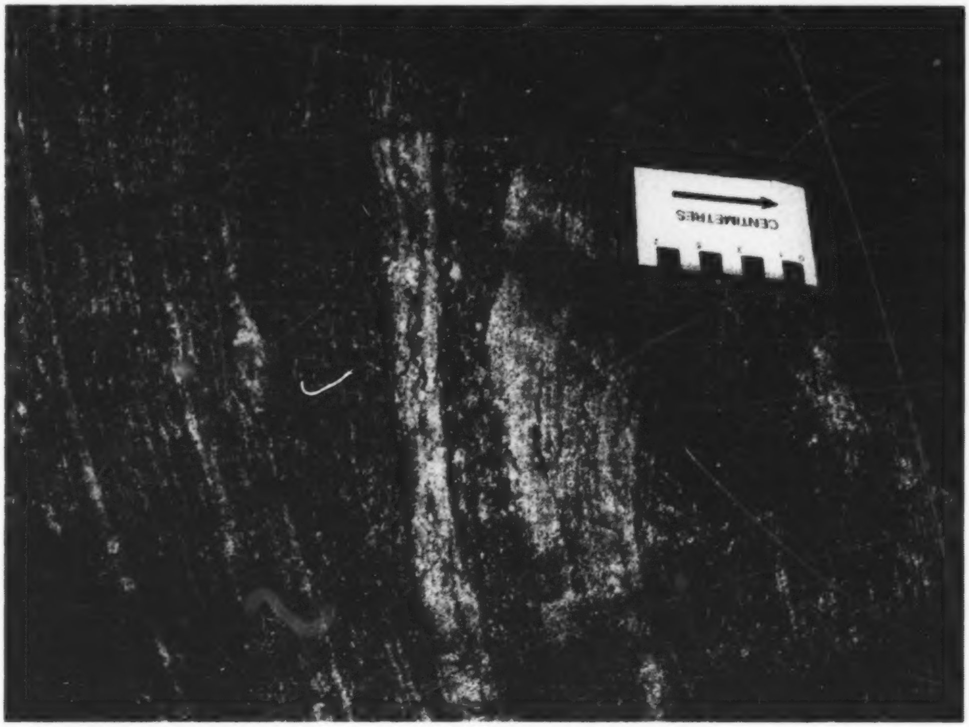


**Photo 10.** In situ metatexite developed along the south margin of the Round Lake batholith in Burt Township. Note melanosome rims along edges of leucosome bands. Outcrop located at UTM 552721E, 5317522N, zone 17.

There is a pronounced contact strain aureole around the margin of the intrusion in Eby Township defined by strongly foliated mafic metavolcanic rocks and poorly developed subvertical stretching lineations on the foliation planes. A contact metamorphic aureole accompanies the strain aureole and is detectable up to 500 m from the granodiorite. The aureole attained upper greenschist grade temperatures as evidenced by the development of garnet and secondary amphibole adjacent to the contact in mafic metavolcanic and metasedimentary rocks. Chown, Harrap and Moukhsil (2002) reported that the granodiorite is the youngest phase and is dated at 2696.9 Ma.

Geochemistry for selected samples of the Round Lake batholith is presented in Table 9 (in Appendix) and Figure 15. Foliated tonalite displays fractionated REE and extended element patterns with negative niobium, tantalum and titanium anomalies (*see* Figure 15a, b). The patterns are similar to the most felsic members of the Otto stock but contain lower total REE than the Cairo stock. The younger granodiorite contains lower LREE than the tonalite but still displays negative niobium, tantalum and titanium anomalies (*see* Figure 15c, d). A satellite intrusion in Burt Township is similar to the Round Lake batholith tonalite although it is more massive and generally coarser-grained. Feng and Kerrich (1990) demonstrated that the gneissic tonalite around the margins of the Round Lake batholith crystallized at approximately 5 kbar pressure, whereas, the interior quartz monzonite (granodiorite?) and contact metamorphosed wall rocks crystallized at approximately 2 kbar pressure. These authors inferred that the pressure distribution reflected progressive ballooning of the batholith combined with syntectonic erosion.

## Holmes and Burt Townships Intrusions

Granitoid intrusions that underlie central Holmes Township and northwest Burt Township are composed of quartz monzonite, diorite, granodiorite and syenite. This part of the map area contains little outcrop, and previous mapping either did not interpret the subsurface geology or show continuity between the two intrusions (Moore 1966, Jensen 1990). New logging roads improved access and exposure, permitting better discrimination and revision of the geology in parts of this area.

The Burt Township intrusion is composed of pink weathering, equigranular quartz monzonite and rare "spotted" syenite. Amphibole is the main mafic mineral; microcline and plagioclase occur in approximately equal proportions. Apatite, titanite, zircon and magnetite are common accessory mineral. The rock contains from 1 to 5 % small mafic xenoliths and is weakly foliated. Airborne geophysical magnetic data (OGS 2000) suggest that the intrusion is separated from the Holmes Township intrusion by gabbro and the Cross Lake fault.

A single sample from this intrusion was analyzed and results are presented in Table 9 (in Appendix) and Figure 16. The alkalic geochemical affinity is confirmed by the high LREE content and pronounced negative niobium, tantalum and titanium anomalies similar to other alkalic plutons in the map area.

The Holmes Township intrusion is composed mostly of quartz monzonite, with minor granodiorite and diorite. The quartz monzonite is pink weathering, equigranular with amphibole as the major mafic mineral. Quartz comprises from 5 to 20% of the rock except near the contacts where the rocks may contain little or no quartz. The amount of quartz suggests that the intrusion is calc-alkalic; however, the amount of microcline observed in thin section and the occurrence of barite at one location in the intrusion suggests an alkalic geochemical affinity. A marginal diorite phase was observed along the west contact with the quartz monzonite and is inferred to occur along the southeast contact based on airborne magnetic geophysical data (OGS 2000) and compiled geology (Jensen 1990). The diorite is dark green to grey weathering and composed of equal amounts of amphibole and plagioclase except where mixed with the felsic phases of the intrusion, in which case white mica is common. Geochemistry of a single sample of

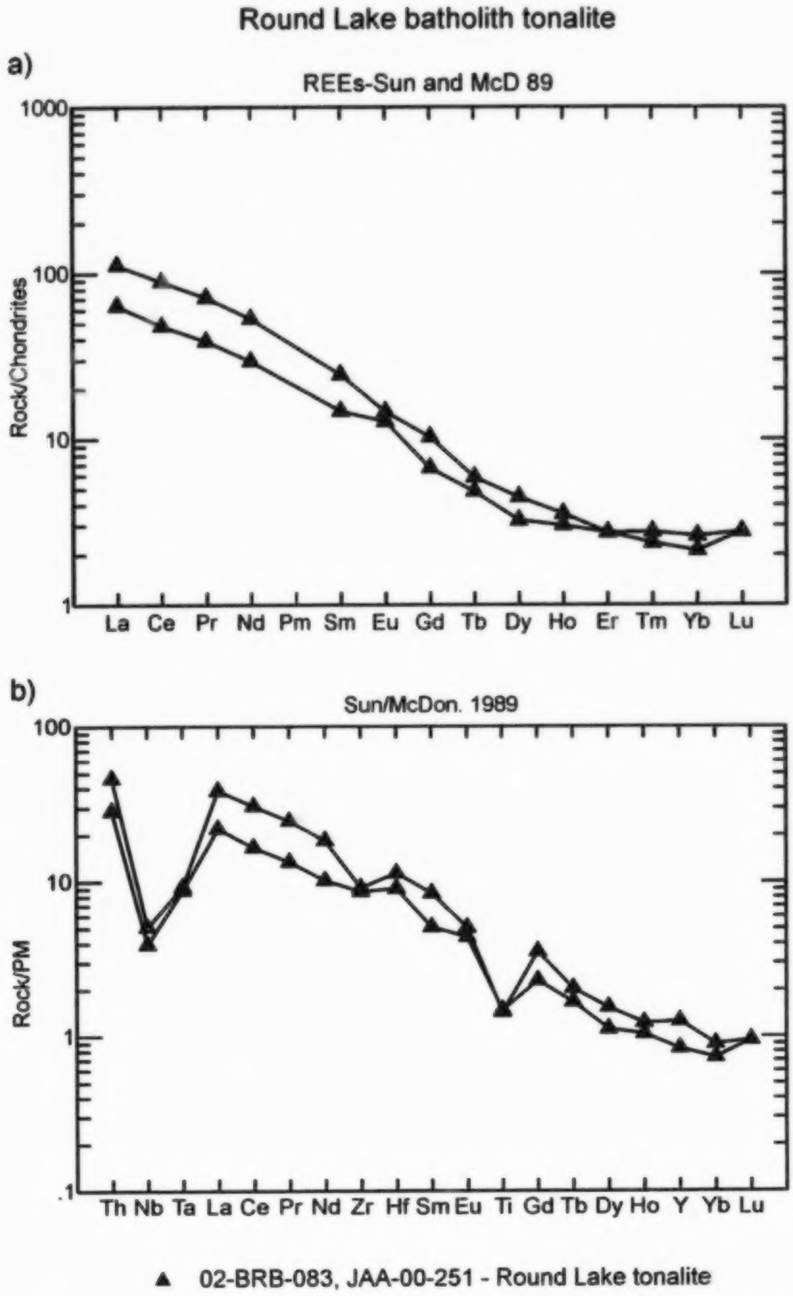


**Figure 15a,b.** Trace element geochemistry for the Round Lake batholith, Highway 66 area.

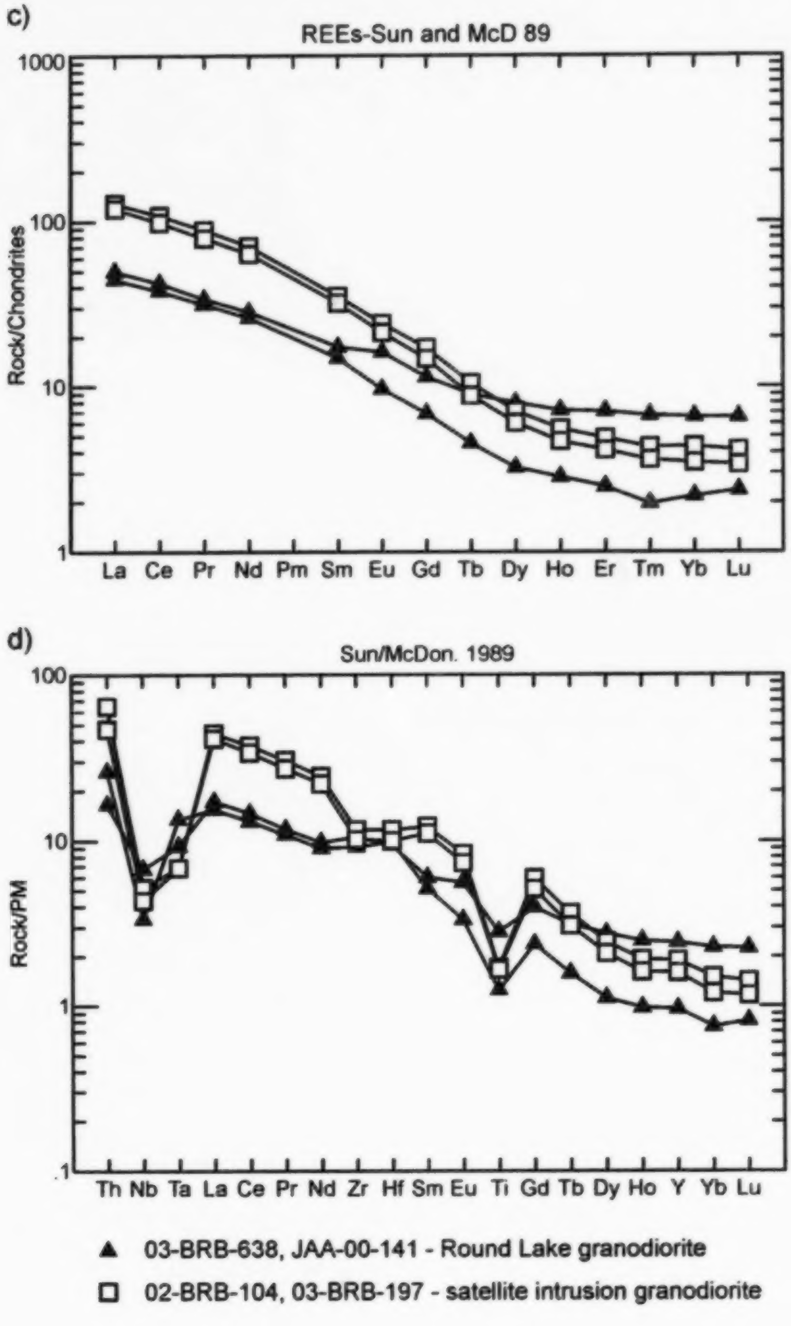


**Figure 15c,d.** Trace element geochemistry for the Round Lake batholith, Highway 66 area.

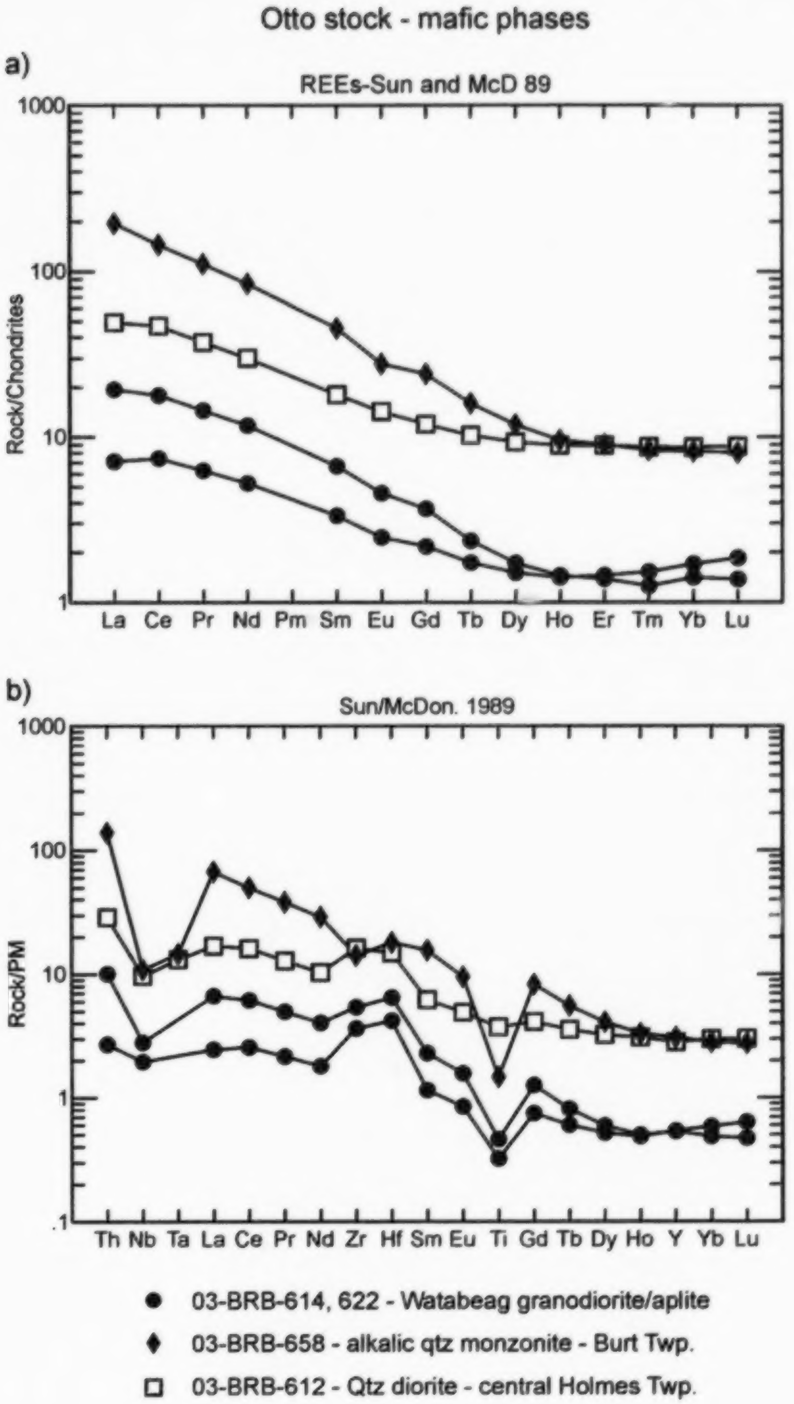


**Figure 16a,b.** Trace element geochemistry for other felsic intrusions, Highway 66 area.

this phase displays moderately elevated LREE, flat HREE and a weak positive hafnium and zirconium anomaly (Table 9, Figure 16). The geochemistry is transitional between the alkalic quartz monzonite of the Burt Township intrusion and the calc-alkalic Watabeag intrusion (see below).

### Watabeag Intrusion

A portion of the Watabeag intrusive complex underlies the north and northwest parts of Holmes Township and extends west and north of the map area (Jensen 1990; Kresz 1993). Pink weathering granodiorite is the most abundant phase of the intrusion in the map area and is equigranular to quartz porphyritic. Although amphibole is the major mafic mineral it is commonly metamorphosed to epidote and chlorite. Sugary textured granitic aplite occurs in many places near the contacts of the intrusion and rarely occurs as dikes in the host rocks. Banded gneiss and agmatite were observed along the southeast margin of the intrusion, indicating that there was interaction and partial melting with the host rocks. Banded granitic gneiss with amphibole streaks and segregations was observed 300 m north of the map area in Dunmore Township. This rock type corresponds to an airborne geophysical magnetic anomaly that marks the northern contact of the intrusion (OGS 2000). Intensely schistose plagioclase phyric intermediate metavolcanic rocks along the western contact have well developed down dip extension lineations developed in the contact strain aureole around the intrusion. These data indicate forceful intrusion and interaction of the pluton with the host rocks.

Geochemistry for the Watabeag granodiorite is presented in Table 9, Figure 16. The felsic rocks have low total REE and are characterized by weak negative niobium and titanium anomalies and positive hafnium and zirconium anomalies unlike other felsic intrusive rocks in the map area. Feng (1992) indicated that the Watabeag Batholith is late- to posttectonic and may represent mixtures of magma derived from a metasomatized mantle and partial melting of a basaltic protolith. Feng and Kerrich (1990) reported that the northern part of the Watabeag intrusive complex was approximately 2681 ± 3 Ma and crystallized at approximately 1 kbar pressure based on aluminum in hornblende geobarometry.

## Proterozoic

### MAFIC INTRUSIVE ROCKS

Diabase dikes are ubiquitous in the map area. North-striking quartz diabase dikes are most common and are correlated with the Matachewan swarm dated at 2476 Ma (Osmani 1991). Two types of diabase were mapped: those dikes that contained greater than 1% porphyritic plagioclase phenocrysts and those dikes that contained less than 1% porphyritic plagioclase phenocrysts. Many of these dikes are medium-grained, orange-brown weathering with well-developed subophitic texture; however, several dikes are medium- to fine-grained, dark green weathering with textures that resemble mafic metavolcanic rocks. In thin section, the mafic minerals in these dikes are weakly to moderately recrystallized, plagioclase is turbid with poorly preserved twinning planes, and secondary epidote and chlorite are common. The dikes have undergone low grade metamorphism and are difficult to distinguish from the Neoarchean metavolcanic rocks.

Dikes vary from a few centimetres wide to over 50 m wide. In places, dikes converge, creating large amoeboid intrusions, or dikes may bifurcate, creating narrow wedges of supracrustal rocks. Dike emplacement was passive as xenoliths are never observed. In a few places north-striking dikes are diverted into east-striking fractures. The dikes extend along these fractures for some distance then strike north again. The author interprets this as further evidence for passive magma emplacement along pre-existing structures.

Northeast to north-northeast-striking diabase dikes occur in a few places in Eby and Otto townships. These dikes are mineralogically similar to the Matachewan dikes but generally display much lower magnetic susceptibility. These dikes also have lower total rare earth element contents than Matachewan dikes although only a few dikes were sampled (*see* Table 10, Figure 18). The northeast-striking dikes are tentatively correlated with the Biscotasing dike swarm (cf. Osmani 1991) although Lovell (1972) correlated these dikes with the Nipissing diabase.

Moore (1966) identified a northwest-striking olivine diabase dike intruding the Gowganda Formation as a member of the Keweenawan dike swarm in Burt Township. The author was unable to locate this dike even though there is a prominent airborne geophysical magnetic anomaly that marks its approximate location (OGS 2000). Most Keweenawan dikes strike east-northeast and are located north of the map area (Berger 2000; Osmani 1991). It is more likely that the northwest-striking dike is a member of the Sudbury dike swarm dated at 1238 Ma (Osmani 1991).

Diabase dikes fall into 3 geochemically distinct categories even though they are indistinguishable in the field and petrographically (Table 10, Figures 17 and 18). Figure 17 shows that dikes inferred to be Matachewan swarm contain lower $Al_2O_3/TiO_2$ than the other dike sets and that another set has distinctly higher Gd/Yb. Figures 18a and b show the REE and extended element patterns for the diabase dikes with

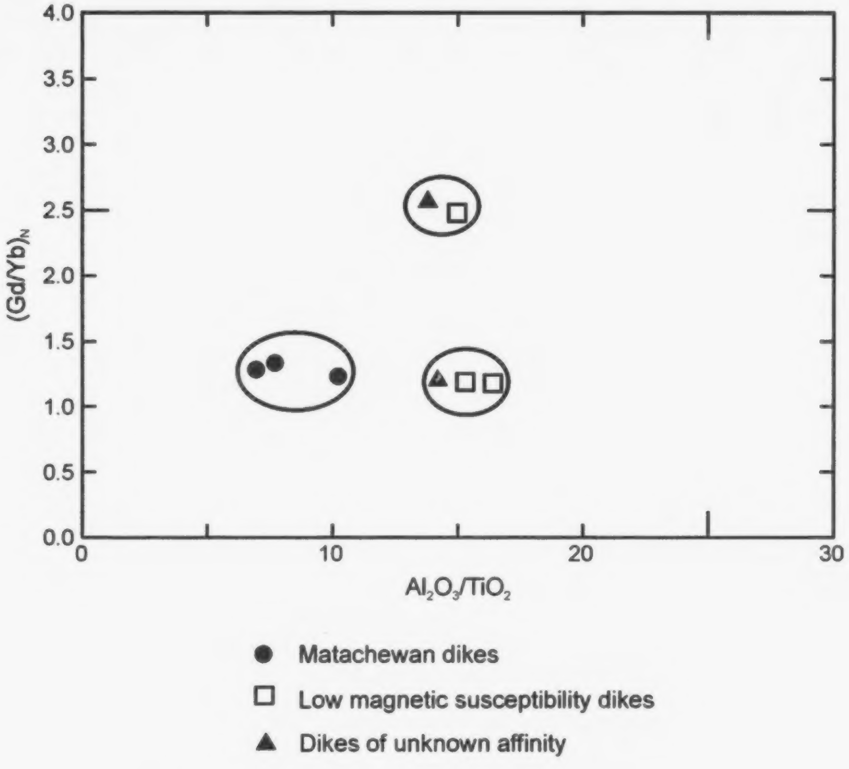


**Figure 17.** Classification of diabase dikes in the Highway 66 area.

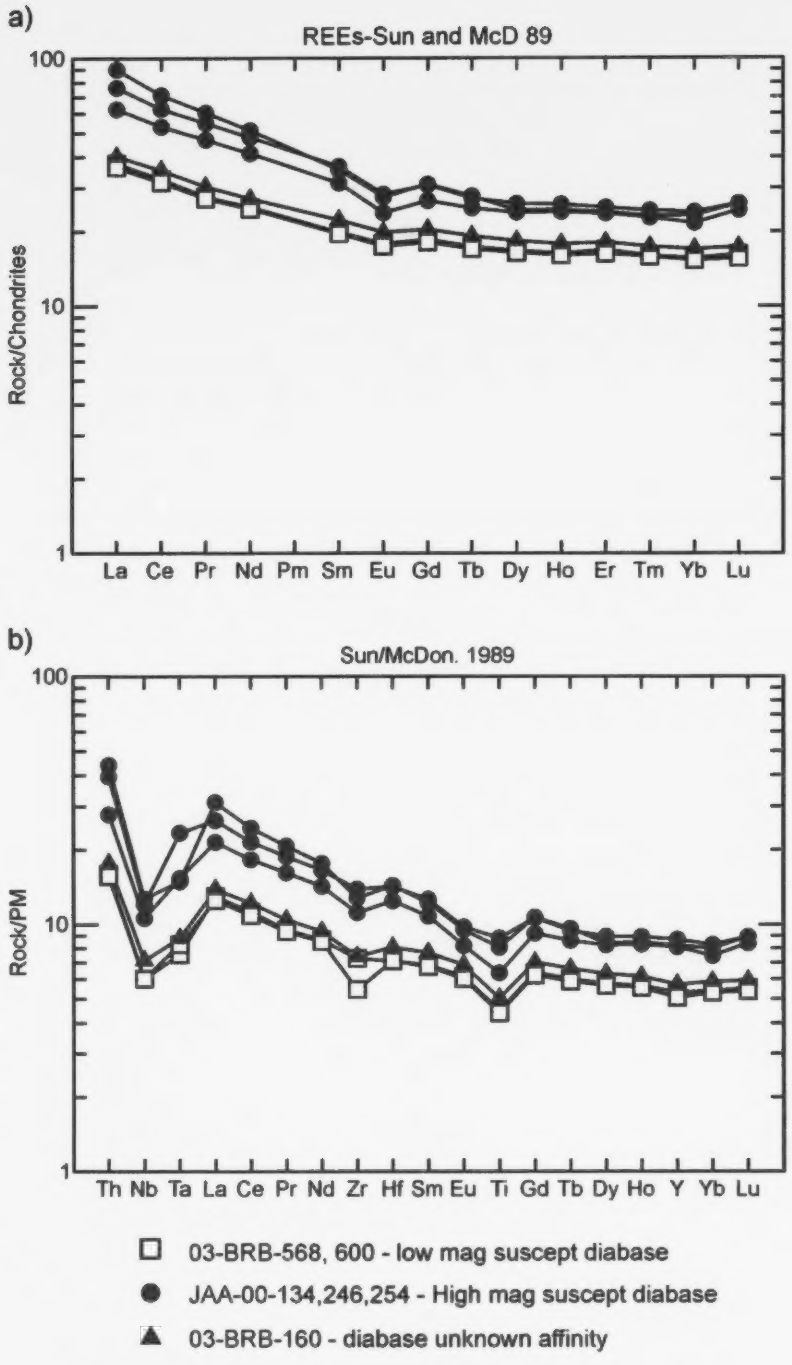


**Figure 18a,b.** Trace element geochemistry for diabase dikes. Highway 66 area.

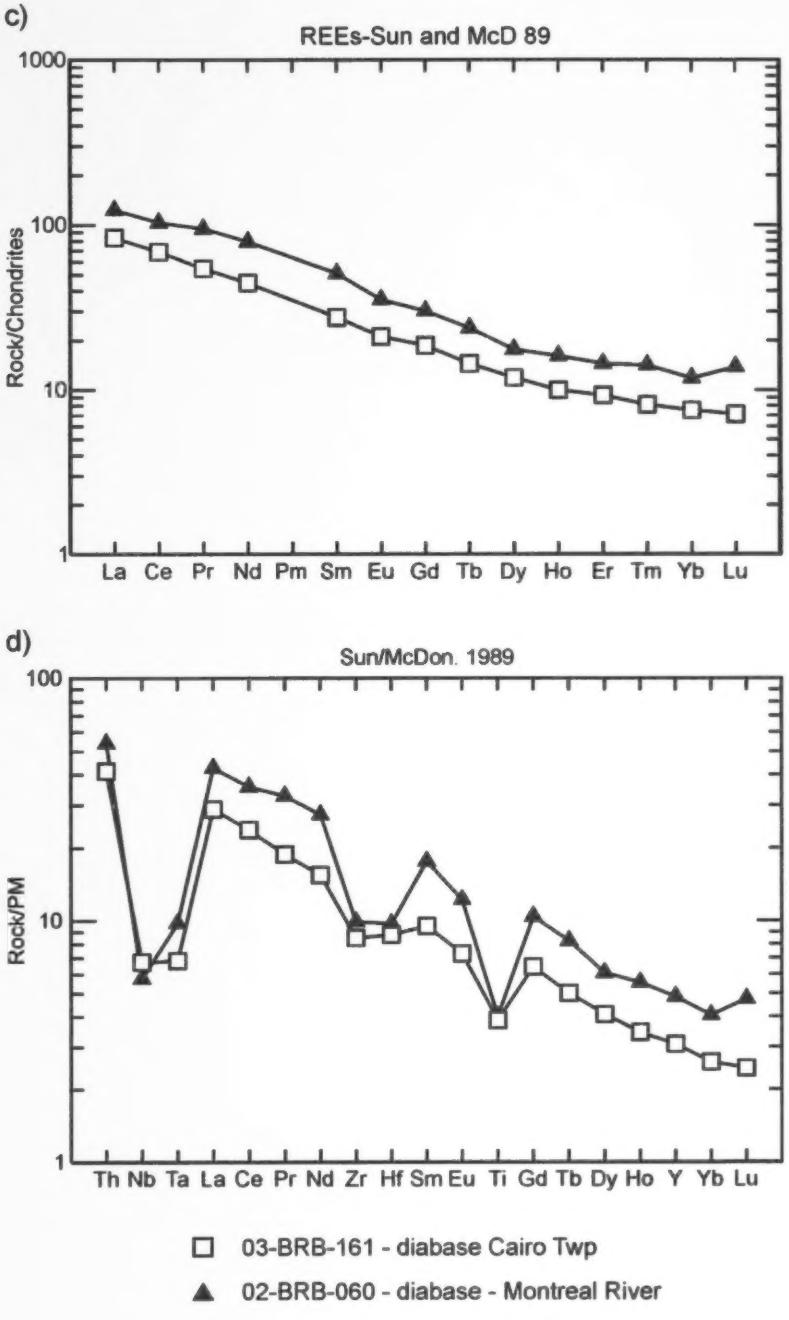


**Figure 18c,d.** Trace element geochemistry for diabase dikes, Highway 66 area.

low and high magnetic susceptibilities. Patterns for both sets of dikes are similar but total element abundance is lower for low magnetic susceptibility dikes. The negative niobium, tantalum and titanium anomalies indicate that the magmas are crustally contaminated as the diabase is generally assumed to be tholeiitic (Osmani 1991). Figures 18c and d show atypical REE and extended element patterns for two dikes in Cairo Township. These dikes contain greater abundance of REE and thorium and have more pronounced negative niobium, tantalum and titanium anomalies than other dikes.

## GOWGANDA FORMATION

Approximately 15% of the map area is covered by Paleoproterozoic clastic metasedimentary rocks correlated with the Gowganda Formation of the Cobalt Group of the Huronian Supergroup (Moore 1966; Lovell 1972). The rocks in the map area are correlated with the Coleman Member of the Gowganda Formation and are composed of conglomerate, lithic sandstone and lithic arenite, wacke, siltstone and argillite (cf. Lovell 1972; Powell and Hodgson 1992). Polymictic clast and matrix-supported conglomerate is most common near the base of the Gowganda Formation but occurs throughout. Matrix supported conglomerate with predominantly rounded granitic clasts up to 50 cm in diameter is common in many places. Typical exposures along Highway 11 at Kenogami consist of conglomerate with up to 70% clasts composed of pink granite, mafic metavolcanic rocks and rare sulphide mineral-bearing chert. The conglomerate is unsorted and massively bedded but is interstratified with thickly bedded sandstone and pebbly conglomerate. Mustard and Donaldson (1987) interpreted such conglomerate as diamictite derived from ice-proximal glaciomarine deposition. In the central part of the unit (higher stratigraphy?) the proportion of clasts to matrix drops dramatically and rocks composed mostly of siltstone or argillite may contain as low as 1% clasts. In these rocks the clasts may be seen to locally deform the underlying beds and can be classified as “dropstones”. Dropstones are interpreted to result from the release of entrained debris from glaciers into standing water; the stones drop onto unconsolidated sediments and create the distinctive impact impression (Mustard and Donaldson 1987). Subsequent sedimentation then covers the dropstone.

Conglomerate also occurs in several places at the unconformity with the Neoarchean basement. This conglomerate is generally clast supported with very little matrix and has a much more diverse clast population than the diamictite. The conglomerate is unsorted with angular to rounded clasts from less than 1 cm to over 90 cm in diameter (Photo 11). Clasts of white tonalite similar to the Round Lake batholith and mafic metavolcanic rocks are common; gneiss, quartz vein material and metasedimentary clasts were also observed. The restriction of this type of conglomerate to the vicinity of the unconformity suggests that it is alluvial-fluvial in origin or possibly fault scarp derived. The unconformity, as observed in several locations, varies from horizontal to moderately dipping to vertical where it overlies the gabbroic intrusion in Flavelle Township. This indicates that the Gowganda Formation was deposited on rugged paleotopography, further supporting an alluvial-fluvial origin for the basal conglomerate.

In most places there is no regolith developed between the Neoarchean basement and the Gowganda Formation. At one location in Flavelle Township yellow weathering subarkosic wacke that has a high proportion of white mica matrix overlies gabbro. The author interprets the white mica, which is unlike any other wacke in the Gowganda Formation, to result from paleoweathering.

Other fine-grained metasedimentary rocks include sandstone, siltstone and argillite. These rock types are most common in the central parts of Burt, Holmes and Flavelle townships and are brown, grey, black or red weathering. The rocks are thinly bedded and commonly interlayered. Ripple marks, load casts and dropstones are common primary features; grain gradation is rare. Lithic fragments, quartz and feldspar are common in thin section. Matrix material is composed of very fine-grained material at the resolution of microscopy but epidote, chlorite and rare biotite indicate that these rocks underwent low grade metamorphism.

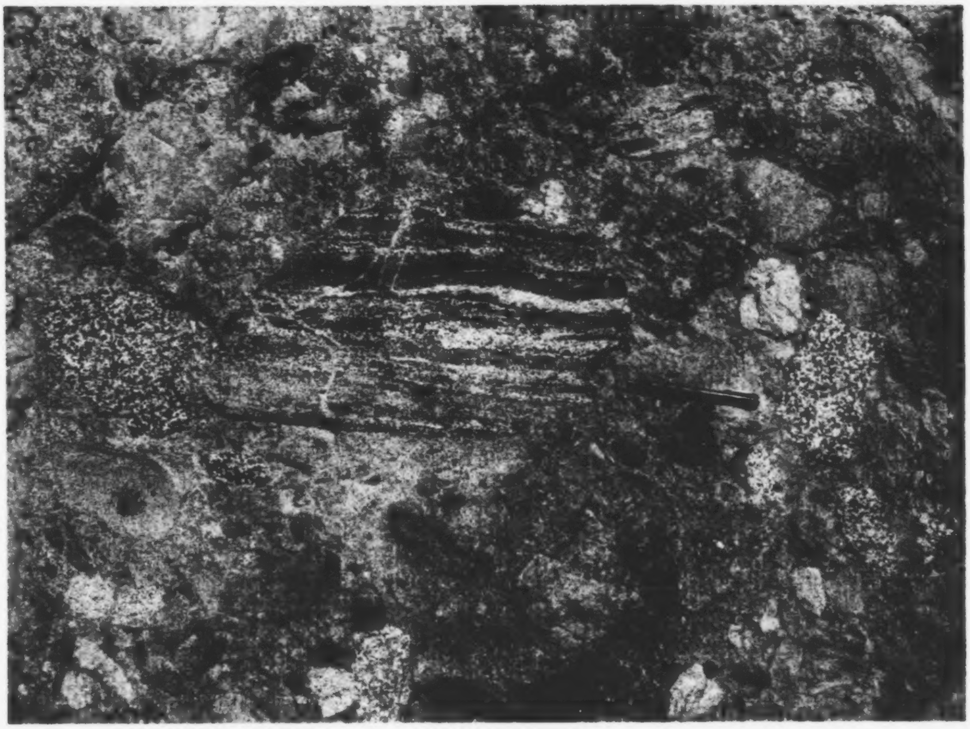


**Photo 11.** Basal conglomerate of the Gowganda Formation, composed of angular to rounded diverse clasts with little matrix, is interpreted as alluvial-fluvial in origin. Outcrop in Flavelle Township, UTM 543112E, 5316862N, NAD 83, zone 17. Pen magnet is 12.5 cm long.

## Phanerozoic

### CENOZOIC

### QUATERNARY

#### Recent and Pleistocene

The surficial Quaternary geology is summarized by Bajc (1997, 2000) and Baker (1985). Large parts of the map area are underlain by bedrock with thin surficial cover composed of glacial till and Recent lake, stream and wetland deposits. The location of the Cross Lake fault is marked by thick shallow water glaciolacustrine and eolian deposits that are exploited locally for sand and gravel. Bajc (1997) indicated that ice flow was directed toward the south and southeast. Much of the area is covered by a thin veneer of till that is characterized by variable stone content, silty to sandy matrix and low matrix carbonate (Bajc 1997).

# Structure and Metamorphism

The Highway 66 area is complexly deformed and metamorphosed. This section will describe the main structural elements, major faults and deformation zones and relate these features to mineralization in the map area. Correlation across the map area is greatly enhanced by the outcrop density used in conjunction with airborne magnetic geophysical data (OGS 2000, 2004) and supplemented with ground geophysical surveys filed for assessment work credits that are available at the resident geologist's office in Kirkland Lake and from Earth Resources and Mineral Exploration webSite (ERMES). The effects of regional and contact metamorphism combine to create complex metamorphic patterns that, in general, reflect higher temperatures than occur elsewhere in the Abitibi greenstone belt.

## STRUCTURE

### Contact Strain Aureoles

Approximately 45% of the map area is underlain by intrusive rocks of the Round Lake and Watabeag batholiths, the Cairo and Otto alkaline stocks and smaller intermediate and felsic intrusions. Foliation is developed in all Neoarchean supracrustal rocks around the peripheries of the granitic intrusions and commonly dips away from intrusion contacts. In many places, down-dip mineral and stretching lineations accompany the foliation planes, strongly suggesting that most foliation is developed in contact strain aureoles around the intrusions. The most pronounced aureole is around the Round Lake batholith where foliation and lineations related to intrusion are developed up to 800 m from the batholith contact. Harrap and Helmstaedt (1992) indicated that intrusion-related faults occurred in the supracrustal rocks adjacent to the Round Lake batholith. One such fault is exposed along Highway 65 in Cairo Township, where sheared intermediate metavolcanic rocks contain abundant carbonate along foliation planes and kinematics indicate south-side up (batholith-side up) reverse movement on the fault.

A well-defined contact strain aureole around the Otto stock (up to 500 m wide) is marked by a concentric foliation around the contacts in the supracrustal rocks and by primary mineral alignment (potassium feldspar laths) at the margin of the stock. Steep, down-dip mineral lineations occur along foliation planes in a few places and the high strain in the supracrustal rocks is accompanied by development of feldspar-rich partial melt stringers, gneissic textures and high temperature minerals such as garnet, secondary amphibole and rare aluminosilicate (andalusite?) in country rocks of appropriate composition.

Strain aureoles were also detected in the supracrustal rocks around the southern lobe of the Watabeag Batholith and the quartz monzonitic plutons in Holmes Township and to a lesser extent around the Cairo stock. In Holmes Township foliation is parallel to the contacts of the intrusions and down-dip extension and mineral lineations are weakly to strongly developed. Extensive recrystallization and local gneiss is developed, indicating that upper greenschist to amphibolite temperatures accompanied strain. Concentric foliation is weakly developed around the Cairo stock and is accompanied by hornfels in mafic metavolcanic rocks and amphibole and biotite porphyroblasts in clastic metasedimentary rocks.

The Cairo stock is dated at 2676 ± 1 Ma and is the youngest intrusion known in the map area. The age date provides a minimum age for development of all contact strain aureoles in the map area.

## Shear Zones

Shear zones characterized by brittle-ductile deformation occur throughout the map area and overprint deformation related to contact strain aureoles. The largest and most important is the Larder Lake–Cadillac deformation zone (LCDZ), a regional structure that extends across the map area. The deformation zone is exposed in north Eby and south Cairo townships and can be traced by airborne magnetic geophysical and ground gravity surveys under the Gowganda Formation in the central part of the map area (OGS 2004, 2000). It cuts across the south part of the Cairo stock and all deformation related to the LCDZ postdates 2676 ± 1 Ma (see above). The LCDZ is characterized by dextral movement along its entire length in the map area. However, the style of deformation is distinctly different east and west of the Cross Lake fault. In north Eby Township the deformation zone is over 450 m wide and is characterized by brittle-ductile features. Most outcrops in the deformation zone display 2 foliations with $S_1$ striking approximately 70° parallel and $S_2$ always oriented counterclockwise to $S_1$ (most commonly 45 to 50°). Intense shearing is restricted to narrow, anastamosing zones a few metres wide that are composed of carbonate and green mica schist. Stretching lineations, slickensides and steps on fault planes plunge shallowly to moderately to the east-northeast and indicate a small amount of south-side up movement occurred across the deformation zone. Overall, brittle and ductile deformation features are common.

West of the Cross Lake fault the LCDZ is exposed along Highway 66 in Flavelle and Cairo townships. Here the LCDZ is a single sharply bounded zone of intensely sheared to fissile rock that is approximately 150 m wide. One foliation (70°) is dominant although locally 2 foliations were observed. Z- folded quartz veins, Z-asymmetry on crenulation cleavage, local C-S fabric development and rotated blocks all indicate that dextral movement was dominant (cf. Colvine et al. 1988). Stretching and mineral lineations are developed in preference to more brittle features like slickensides and fault-plane steps and are subhorizontal to shallowly east plunging. This evidence indicates a small component of south-side up movement on the deformation zone. Overall, ductile deformation features are more common than brittle features. The along-strike changes in deformation style implies east-side down movement across the Cross Lake fault.

A number of narrow east-striking faults and shear zones occur throughout the map area. These structures are more numerous west of the Cross Lake fault and airborne magnetic geophysical data suggests that these features are splays from the LCDZ (OGS 2004, 2000). Many of these structures have local names that include the Galer Lake fault, Kincaid fault and Wiley Lake fault (*see* map in back pocket). Each of these structures display oblique dextral movement as determined by C-S fabric, small scale Z-folds or offset of lithological contacts (*see* Photo 12). Stretching lineations are developed on each of the shear zones and plunge shallowly to moderately to the southwest, indicating north-side up oblique movement. Lineations tend to plunge more steeply on each successive shear zone going northward such that lineations plunge shallowly on the Wiley Lake shear zone in Flavelle Township and moderately on the Galer Lake fault in Holmes Township. This indicates successive increments of north-side up movement occurred on each of the splay faults. The LCDZ occupies a half graben west of the Cross Lake fault.

The Kincaid fault is an arcuate east-striking structure in central Holmes and Alma townships. It is poorly exposed but can be traced by airborne magnetic geophysical data as magnetic low lineament (OGS 2000). Stripped outcrop north of Able Lake in Holmes Township shows that the deformation is approximately 25 m wide and is characterized by progressive shearing and transposition of lithology and an earlier foliation (*see* Photo 13). This style of deformation is not observed elsewhere in the map area and may represent deformation related to the LCDZ overprinting foliation related to a contact strain aureole around the felsic pluton approximately 200 m north of the stripped outcrop.

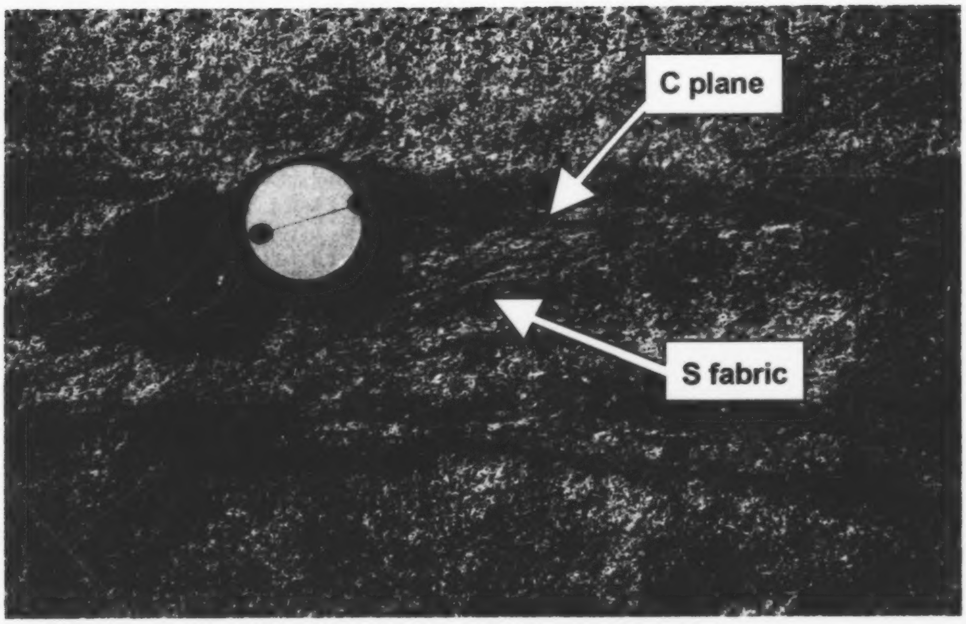


**Photo 12.** Narrow dextral shear zone with C – S fabric in Cairo stock syenite from McChesney property; Flavelle Township. Typical kinematics for shear zones west of the Cross Lake fault. Pen is 15 cm long. UTM coordinates 535619E, 5316745N, NAD 83, zone 17.

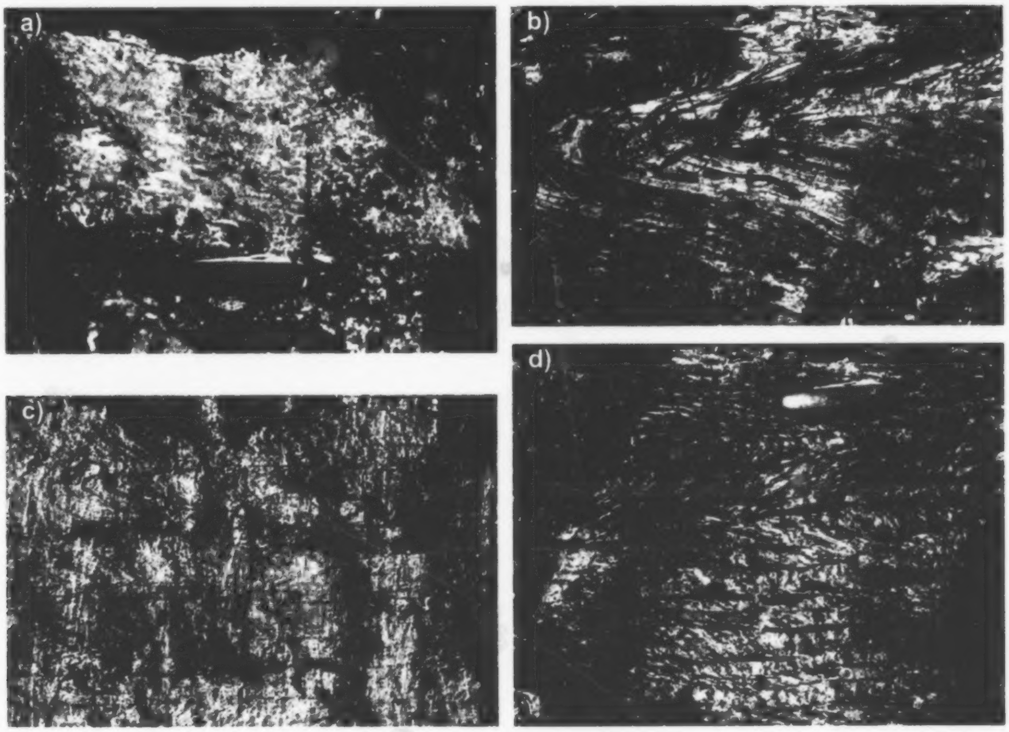


**Photo 13.** Stripped outcrop located at 540443E, 5321062N, NAD 83, zone 17, Holmes Township. Knife is 8 cm long. **a)** alkalic lapilli tuff protolith north of Able Lake. Note alignment of clasts parallel to $S_1$. **b)** Simple fold of rock and $S_1$ foliation. Axial plane of fold is parallel to $S_2$, the main foliation in the Kinkaid fault. **c)** Progressive deformation of $S_1$ by $S_2$. Folds are transposed by movement along $S_2$ planes . **d)** Extensive transposition of $S_1$ in the Kinkaid fault.

## Folds

Reversals in stratigraphic facings were mapped in Eby and Cairo townships and indicate that supracrustal rocks are folded in these locations. Reversals in facings in clastic metasedimentary rocks in Cairo Township define a synformal anticline with an easterly striking fold axis. The geometry of the fold indicates that it must have refolded an earlier structure and is, therefore, a second generation fold ($F_2$). Fold axes in Eby Township are inferred from few reversals in facings and interpretation of airborne magnetic geophysical data (OGS 2004, 2000). The fold axes are deflected, tightened and reoriented in the vicinity of the Otto stock suggesting that folding occurred prior to intrusion of the Otto stock (ca. 2680 Ma). North-striking fold axes interpreted by Lovell (1972) in the north part of Eby Township could not be confirmed by the present survey, as pillowed mafic flows were found to consistently face southwest or south in this area. Tight isoclinal folds were observed in Timiskaming assemblage metasedimentary rocks north of the map area in Teck Township; however, reversals of stratigraphic facings were not observed anywhere in the map area, so fold axes could not be placed on the map in the Timiskaming assemblage.

## North-South Faults

Many north-south faults crosscut stratigraphy throughout the map area. Three major faults have a profound effect on the geology: the Montreal River, the related Whiskey Jack Creek and Knott Lake faults, the Cross Lake fault and the Amikougami fault.

### MONTREAL RIVER FAULT

The Montreal River, Whiskey Jack Creek and Knott Lake faults underlie west Cairo Township and extend both north and south of the map area. The Knott Lake fault is exposed on Highway 66 where steep bedding planes and well-developed foliation in Gowganda Formation conglomerate and sandstone indicates that the fault was active during the Proterozoic. Lovell (1967) observed left-lateral movement across the 3 faults and inferred east-side down movement on the Montreal River fault. The present survey supports Lovell's observations and interpretations. Matachewan diabase dikes appear to exploit the Montreal River fault, which would indicate that the fault was present prior to dike intrusion. It is likely that an Archean precursor fault was present and was subjected to repeated activation during the Proterozoic and during the Paleozoic.

### CROSS LAKE FAULT

The Cross Lake fault is a northwest-striking structure that extends through the central part of the map area and is traced by mapping and geophysical airborne surveys from Cobalt to east of Timmins (Ayer and Trowell 2000; OGS 2000). The fault is covered by thick glaciolacustrine and eolian deposits and was not observed directly in the map area. However, the fault is characterized by a magnetic lineament that permits its location to be placed on the map (OGS 2004, 2000; *see also* map in back pocket). As described above there is a change in the style of deformation on the LCDZ across the fault which is interpreted by the author to suggest east-side down movement on the fault. Lovell and Caine (1970) indicated that the fault was active during the Timiskaming rift event in the Paleozoic and a component of vertical movement is inferred to occur in the Paleozoic. Numerous kimberlite intrusions are associated with the Cross Lake fault on the west flank of the Timiskaming rift valley in the Timiskaming Shores area (Sage 1998b). It is possible that the Cross Lake fault acted as a conduit for kimberlite intrusions in the map area as well.

## AMIKOUGAMI FAULT

The Amikougmi fault is north striking and extends through the center of the Otto stock in Otto Township. The fault continues north of the map area into Teck Township where it is described by Thomson (1948). The Kirkland Lake fault main break and associated gold-bearing quartz veins terminate at the fault and have not been traced to the west (Tompson 1948). There is left-lateral movement across the fault that appears to increase in magnitude to the south and few lineations observed underground are northeast plunging (Tompson 1948). These observations indicate east-side down movement in Teck Township; however, the increased left-lateral offset in Otto Township may be explained if movement on the Amikougami fault is scissor-like with east-side-up movement in the map area. As with the other north-striking faults in the map area most of this vertical movement is inferred to have occurred in the Proterozoic with later Paleozoic reactivation.

The Amikougami fault has affected the Otto stock with alkalic granite and quartz syenite occurring only west of the fault (*see* Figure 19). These phases broadly correspond to areas of relatively low magnetic response in airborne magnetic geophysical data (OGS 2000); whereas, east of the fault, oval magnetic patterns correspond to coarse-grained syenite and "spotted" syenite (see above) (*see* Figure 19). The author interprets the magnetic patterns and geology to result from separate intrusive lobes that exploited the Amikougami fault. If this is true then the Amikougami fault must be an Archean structure and is possibly related to late stage movement on the Larder Lake–Cadillac deformation zone. It should be noted that other alkalic intrusions, such as the Lebel Stock in Lebel Township and the Garrison stock in Garrison Township are also bisected by late stage north-striking faults (Berger 2002; Cruden and Launeau 1994). The implication is that the Amikougami and other similar north-striking faults are long-lived structures that have undergone repeated reactivation from the Neoarchean to the Paleozoic.

## METAMORPHISM

Metamorphic patterns in the Highway 66 area are dominated by the effects of contact thermal aureoles weakly overprinted by regional low-grade greenschist metamorphism. Contact thermal metamorphic aureoles were observed around every granitic pluton in the map area, with the most extensive developed around the Round Lake batholith. All Neoarchean supracrustal rocks within 500 m of the Round Lake batholith are affected by the intrusion. In south Burt and southwest Eby townships effects of the thermal aureole were detected up to 1500 m from the batholith. Garnet is developed in felsic metavolcanic and metasedimentary supracrustal rocks adjacent to the batholith, indicative of upper greenschist- to amphibolite-facies metamorphism (*see* Photo 14). The garnet crystals are usually subhedral with abundant inclusions with foliation wrapped around the crystals and with the crystals overgrowing foliation (*see* Photo 14). Rarely, the garnet is anhedral, poikioblastic and elongated in the plane of foliation. These features are interpreted to indicate syntectonic to posttectonic crystal grow in a contact thermal aureole.

Secondary amphibole and calcic plagioclase are characteristic of mafic metavolcanic rocks in south Burt Township and most convincingly, the absence of significant amounts of chlorite indicates upper greenschist- to amphibole-grade metamorphic conditions were attained (cf. Winkler 1979). Gneissic textures and partial melt segregations were observed in several places adjacent to the Round Lake batholith in Burt and Cairo townships. Epidote and feldspar occurring locally with garnet form bands and stringers up to 15 cm wide parallel to the foliation in mafic metavolcanic rocks within 300 m of the contact of the batholith. The thickness and density of banding increases as the contact is approached. This is interpreted as a type of calc-silicate alteration and partial melting of the host rocks during intrusion of the batholith.

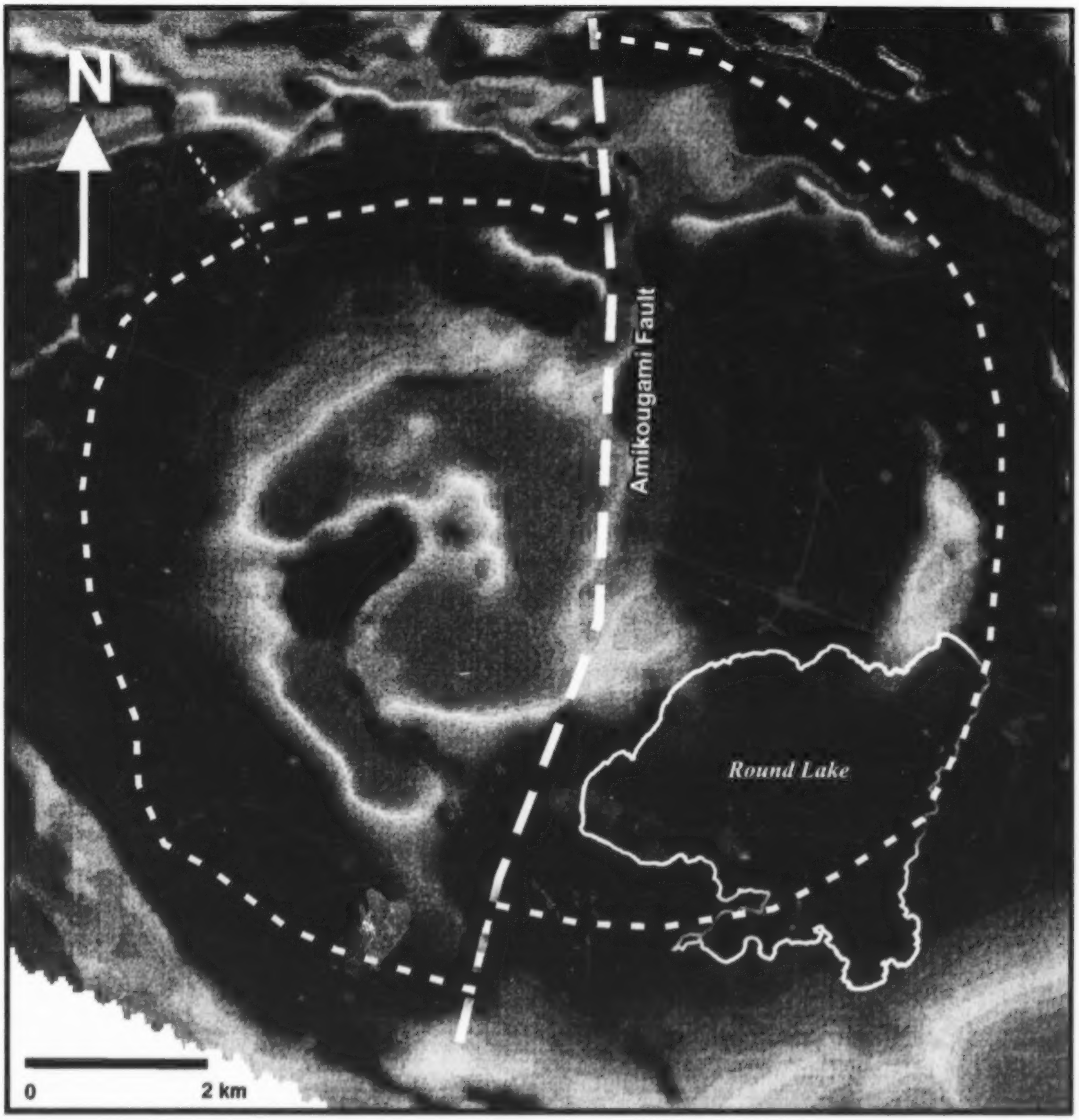

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**Figure 19.** Total field airborne magnetic geophysical data for the Otto stock with contacts and Amikougami fault superimposed. Quartz syenite occurs only west of the fault, and the magnetic pattern may represent 2 intrusive lobes of the stock (cf. OGS 2000).

At distances greater than 300 m from the contacts in Flavelle and Cairo townships, greenschist-grade contact metamorphic effects include development of epidote-chlorite and feldspar pods in mafic metavolcanic rocks. Hornfels is poorly developed in gabbro and intermediate metavolcanic rocks and is recognized as very hard, fine-grained rocks with a "baked' appearance.

A pronounced thermal contact metamorphic aureole is developed up to 500 m around the Otto stock. Garnet is developed in iron formation around the north margin of the intrusion (*see* Photo 4a) and also occurs with epidote in stringers in mafic metavolcanic rocks along Highway 11 in Eby Township. Gneiss is locally developed adjacent to the northeast and northwest contacts of the intrusion. Hornfels is developed in mafic metavolcanic rocks up to 500 m from the contacts in northeast Otto Township. This area is also proximal to the Lebel Stock east of the map area, and the author suspects that the high grade metamorphism is the result of the influence of both the Otto and Lebel stocks.

Supracrustal rocks are strongly recrystallized, gneissic and contain feldspar-quartz stringers attributed to partial melting along the southwest contact of the Otto stock. This area is part of a narrow septum of greenstone "sandwiched" between the Otto stock and the granodiorite phase of the Round Lake batholith. The high-grade supracrustal rocks are interpreted to result from the proximity to the 2 intrusions.

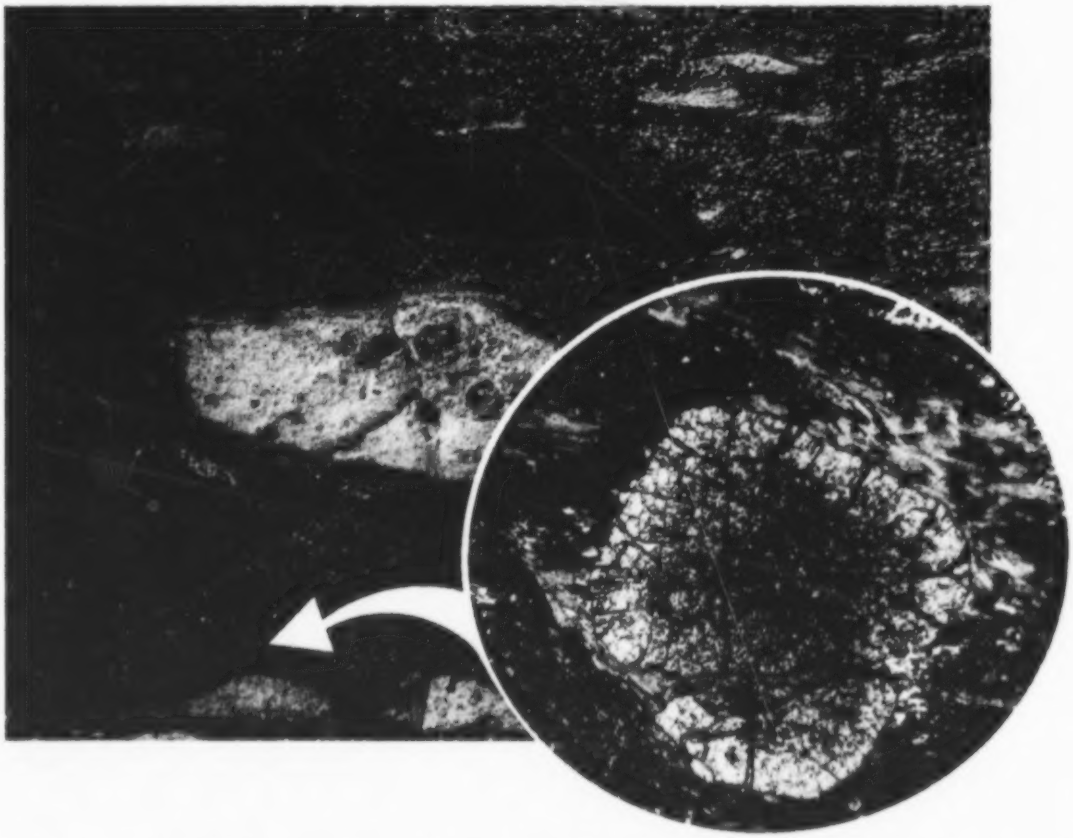

**Photo 14.** Garnetiferous epiclastic metavolcanic rock adjacent to Round Lake batholith - indicative of high grade metamorphic aureole. Chlorite in garnet pressure shadow interpreted as regional metamorphic overprint. Garnet in inset is approximately 1.5 mm diameter. Pen is 15 cm long. Outcrop is located in Flavelle Township at 543206E, 5316105N, NAD 83, zone 17.

Amphibolite-grade supracrustal rocks also underlie parts of north Burt and north Holmes townships in the proximity of the Watabeag Batholith and the smaller alkalic to calc-alkalic plutons in this area. Gneissic segregations, epidote stringers and strong recrystallization of intermediate fragmental metavolcanic rocks are typical textures in this part of the map area and indicate that the area experienced high temperatures and ductile deformation. In northwest Burt Township calc-silicate stringers composed of epidote, chlorite, feldspar ± carbonate is interpreted as metamorphism of a pre-existing hydrothermal alteration associated with base metal mineralization (Photo 15). In the same area strong recrystallization of the intermediate metavolcanic rocks, abundant secondary amphibole and the general absence of chlorite in the groundmass indicate high-grade metamorphism associated with the intrusions.

The Cairo stock is surrounded by a narrow contact thermal aureole less than 300 m wide. Mafic metavolcanic rocks are typically hornfels, fine grained and well indurated. Epidote veining is common. Clastic metasedimentary rocks in the metamorphic aureole are fine grained, biotite- and epidote-bearing with low abundance of chlorite. Thin sections of alkalic metavolcanic rocks adjacent to the east contact of the Cairo stock are clouded with abundant oxide minerals and there is substantial pseudomorphing of primary amphibole by actinolite and chlorite. Within 100 m alkalic rocks of similar composition are less clouded with oxide minerals and display little, if any, secondary amphibole.

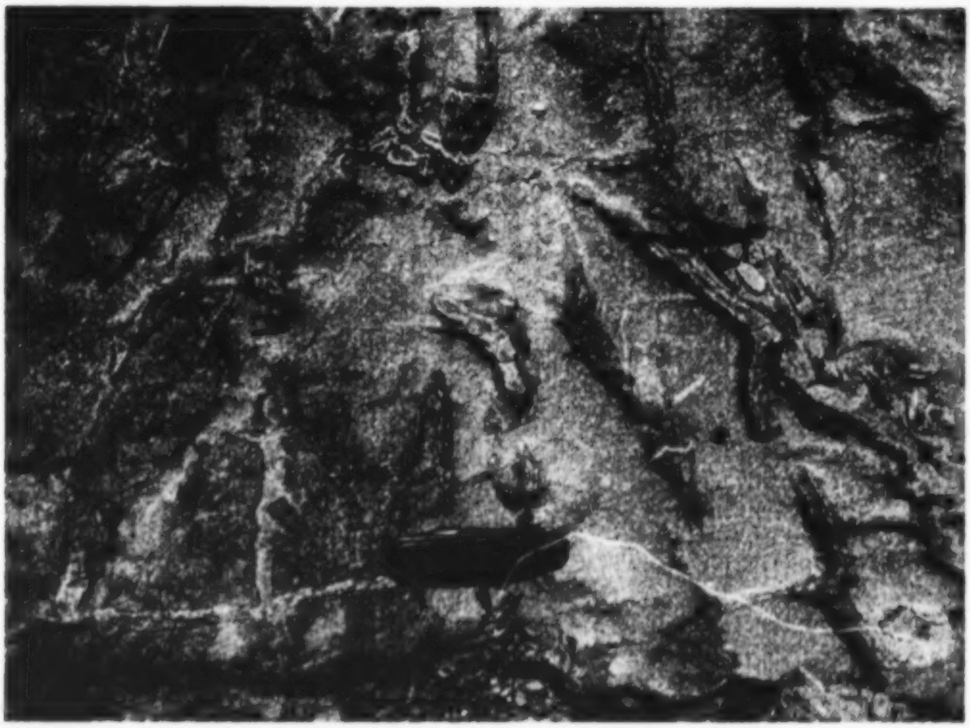

**Photo 15.** Epidote - chlorite - feldspar ± carbonate stringers in intermediate metavolcanic rocks are interpreted to represent metamorphosed hydrothermal alteration associated with base metal mineralization in northwest Burt Township. Knife is 8 cm long. Outcrop located at 544718E, 5326582N, NAD 83, zone 17.

Regional greenschist-grade metamorphism has affected the Neoarchean supracrustal rocks and is inferred to overprint the effects of the contact thermal aureoles. High-grade minerals developed in the contact thermal aureoles commonly display retrograde mineral assemblages. For example, garnet developed adjacent to the Round Lake batholith commonly has chlorite in cracks and in pressure shadows developed by late regional foliation (*see* Photo 14). Prograde biotite in clastic metasedimentary rocks adjacent to the Otto stock is rimmed with chlorite or has chlorite replacing biotite along twinning planes.

Mafic metavolcanic rocks in central Eby Township contain a typical metamorphic mineral assemblage of chlorite + epidote + actinolite ± biotite ± carbonate. This assemblage corresponds to greenschist-grade metamorphism (cf. Winkler 1979). Less common is the mineral assemblage epidote + hornblende ± chlorite indicative of upper greenschist to amphibolite facies metamorphism. The plutonic rocks are metamorphosed, indicating that regional metamorphism postdates intrusion of all the granitoid rocks. Tonalite in the Round Lake batholith commonly contains epidote after primary amphibole and white mica after primary plagioclase. Epidote and chlorite replace primary amphibole in granodiorite of the Watabeag Batholith. Epidote and chlorite fill fractures in the Cairo and Otto stocks. However, blue-green amphibole, almost all biotite and all clinopyroxene observed in the various phases of the intrusion are thought to be primary minerals or the result of auto-metasomatism rather than secondary minerals derived by regional metamorphism. Thompson (2005) concluded that metamorphic patterns in the Abitibi greenstone belt were derived by contact thermal aureoles overprinted by regional metamorphism. However, many minerals believed to be primary by the author were inferred to be metamorphic by Thompson (2005) such that regions, like the Otto stock and area, underwent upper greenschist-grade regional metamorphism. More work is required to resolve the derivation of the mineralogy in and around the Otto stock.

The Timiskaming assemblage metasedimentary rocks in Otto and Eby townships do not show the effects of contact thermal metamorphism and have undergone low-grade regional metamorphism. Typical metamorphic minerals in clastic metasedimentary rocks include white mica + chlorite + carbonate ± biotite ± epidote. Alkalic metavolcanic rocks in the same area typically display a metamorphic assemblage of white mica + chlorite + carbonate + iron oxide minerals ± biotite. Primary textures are well preserved in the metavolcanic rocks; however, primary feldspar is mostly replaced by white mica and carbonate; primary amphibole is replaced by chlorite, white mica and iron oxide minerals. Chalcedony, chlorite and possibly zeolite occur in amygdules. These minerals indicate low-grade metamorphic conditions affected this part of the map area.

Clastic metasedimentary rocks of the Gowganda Formation display weak to no metamorphic affects. Diagnostic metamorphic minerals such as chlorite and biotite are observed locally but they may be detrital as only a few grains were observed in any single thin section. White mica, chlorite and biotite occur in sufficient quantities in the matrix of sandstone located at the unconformity with Neoarchean gabbro in southeast Holmes Township to suggest that greenschist metamorphism affected this part of the Gowganda Formation. A potential heat source are the Nipissing gabbroic intrusions exposed south of the map area. Their extent may have been much greater than present and these intrusions are known to have locally metamorphosed the Huronian Supergroup sedimentary rocks (Johns 1986, 1985). Narrow diabase dikes tentatively correlated with the Sudbury dike swarm (Osmani 1991) may also be a local heat source and a few of these dikes are inferred from geophysical data (OGS 2004, 2000) to intrude the Gowganda Formation.

# Economic Geology

Mineral exploration has been almost continuous in the Matachewan area since the discovery of silver in the Elk Lake area in 1906 (Lovell 1967, reports filed for assessment work credits at Earth Resources and Mineral Exploration webSite (ERMES) and the Resident geologist's office in Kirkland Lake). Gold was discovered in 1914 in southeast Alma Township (Moore 1966) and shortly after in Powell Township (Lovell 1967). Numerous mineral occurrences, including gold, base metals, asbestos, barite, and platinum group elements (PGEs), were discovered in the map area and this section will summarize the geological setting of the more important and geologically interesting showings.

## GOLD

Gold has been the most sought after commodity in the Highway 66 area and several mineral occurrences are hosted in several geological environments throughout the map area. This section will describe the most important gold occurrences and examine the various mineralized environments.

Two past producers are situated in Eby and Otto townships. The Crescent Mine is located on the southeast shore of Otto Lake in Otto Township and was active from 1910 to 1913 and from 1941 to 1947 with a total of $152 454 of gold retrieved from 21 021 tons of ore (Lovell 1972, assessment file KL-0915 Resident Geologists Office, Kirkland Lake). Given the range in gold price over the time period this translates into 0.19 to 0.21 ounce gold per ton (opt). Gold-bearing quartz veins occurred in a fault striking 35°, dipping 80° (referred to as the "shaft fault"). The deposit is hosted in mafic and ultramafic metavolcanic rocks and there appears to have been limited exploration beyond the limits of the known gold deposit.

The Baldwin deposit, discovered in 1911, is located in north Eby Township (Lovell 1972). A 420 foot (128 m) shaft with 4000 feet (1219 m) of drifting and crosscutting was carried out and accompanied by surface and underground diamond drilling (Lovell 1972). Eighty-one tons of gold ore worth $1247 was produced between 1929 and 1938 (Lovell 1972). Quartz-carbonate veins are localized in a shear zone striking 65°; however, the best gold mineralization occurred only where the quartz veins are cut by a fault striking 20° accompanied by poorly developed quartz stringers (Lovell 1972). The deposit is hosted in Timiskaming assemblage wacke and pebble conglomerate near the unconformity with mafic metavolcanic flows. The author infers that this deposit is also located within the Larder Lake–Cadillac deformation zone.

These 2 deposits illustrate that significant gold mineralization occurs with north- to northeast-striking faults. Other gold occurrences, most notably the Brookbank showing in southeast Alma Township, are also localized in north-striking quartz veins and a number of other showings are reported to occur in the Cairo stock (AFRI file number 41P15NE8326). The north-striking faults are locally accompanied by weakly developed foliations especially west of the Cross Lake fault. At the Brookbank gold showing the north-striking foliation/fracture set cuts foliation planes oriented at 255°. In other parts of the map area north-striking foliations and fractures are always observed to be the later structural elements. This indicates to the author that north-striking gold veins are among the younger structural elements in the map area. Sinclair (1982) demonstrated that lead isotope data from galena samples collected at the Brookbank and nearby showings defined a source-rock age of approximately 2700 Ma and a secondary age of 2406 Ma. The secondary age was interpreted to indicate that lead was remobilized, possibly after regional metamorphism, and deposited along with gold and other base metals in the north-striking fractures (Sinclair 1982). Based on the field evidence and other studies that indicate extensive post-Archean tectonism in the area it is possible that mineralization in the north-striking fractures is Proterozoic (*see* Powell and Hodgson 1991; Lovell and Caine 1970; Powell 1991).

Many gold occurrences are structurally controlled by the LCDZ and its associated splay faults in the Highway 66 area. Gold mineralization east of the Cross Lake fault is concentrated in the main part of the deformation zone at or near the contact between the Timiskaming assemblage metasedimentary rocks and the mafic metavolcanic rocks to the south. Carbonate, sericite (commonly as green mica), pervasive silicification and quartz veining are the most abundant alteration minerals present. Pyrite is the main sulphide mineral and is present in virtually every gold showing. Gold hosted in schistose metasedimentary rocks north of Vigrass Lake in Otto Township and gold hosted in carbonatized and silicified mafic metavolcanic rocks near the unconformity with Timiskaming assemblage metasedimentary rocks at the corner of highways 66 and 11 in Eby Township (Rogick, Clark, Elliot occurrences) are 2 examples of mineralization in this environment.

Gold mineralization west of the Cross Lake fault is localized along the main part of the LCDZ and along several of its associated splay faults. Several trenches and stripped areas north of Highway 66 in Cairo and Flavelle townships expose low-grade gold mineralization in sheared syenite and basalt within the main part of the LCDZ. The mineralization is accompanied by hematite, epidote, weak sericite and weak carbonate alteration. Magnetite porphyroblasts are locally developed in the basaltic rocks; pyrite is ubiquitous but generally less than 5% of any of the rocks.

At the Biralger property along the Cairo–Flavelle township boundary disseminated and stringer chalcopyrite and pyrite is exposed in altered syenite of the Cairo stock. Widely spaced diamond-drill holes and surface sampling returned 0.7 gram gold per ton and 0.2% copper over intervals up to 99 m from syenite in contact with sheared basalt (AFRI file 41P15NE2003). Feldspar in the syenite is strongly altered to white mica and secondary hematite, fluorite and barite in all rocks, suggesting mineralization is associated with oxidized alkaline fluids. Sinclair (1982) noted similarities between mineralization associated with the syenitic rocks in the map area to alkalic copper-molybdenum porphyry deposits worldwide. It is more likely, in the author's opinion, that the Biralger mineralization is associated with alkalic porphyry copper-deposits described by Muller and Groves (2000). The potential for large tonnage, low-grade copper-gold mineralization in this part of the map area remains largely untested in the author's opinion.

Many gold occurrences are situated within splay faults and shear zones off of the LCDZ west of the Cross Lake fault. Gold is associated with the Kincaid fault northeast of Able Lake where alkalic lapilli tuff is multiply deformed and mineralized (*see* Map 2677 in back pocket, *see* Photo 13). Gold assays of 9.2 g/t over 6.7 m and 3.3 g/t over 5.6 m collected from surface trenching could not be replicated by diamond drilling and subsequent work has been minimal (AFRI file 42A01SW0050). Hydrothermal alteration is apparent in the stripped areas and consists of pervasive carbonate, sericite and weak hematite with chlorite strongly developed along foliation planes. Quartz veins are narrow and widely spaced and are commonly deformed by the second foliation. Disseminated pyrite is sparse. Approximately 1200 m to the west at Golub Lake several stripped outcrops reveal that the Kincaid fault consists of intensely foliated intermediate tuff with pervasive iron carbonate and silica alteration. Chlorite and tourmaline occur along tiny veinlets and along foliation planes; pyrite is sparse to absent. The ground between these 2 occurrences is poorly explored but it is likely that similar style and intensity of alteration occurs all along the Kincaid fault. Any brittle host or appropriate chemical trap rock along the fault may be gold bearing.

Several gold showings occur along the Galer Lake fault in Holmes Township. The Galer Lake fault is a discrete shear zone approximately 10 to 15 m wide that displays well developed C and S fabric, dextral offset of lithologies and small-scale Z folds. East of Galer Lake the fault is weakly mineralized and carbonate altered with discontinuous quartz veins boudinaged along the main foliation planes. West of Galer Lake sporadic high-grade gold (up to 35 g/t) accompanies widespread low-grade mineralization in sheared syenite in contact with white weathering albitite (Kirkland Lake assessment file K-1087). Chalcopyrite, magnetite, tourmaline, galena, molybdenite, barite and fluorite accompany the gold. Intense sericite, weak to moderate hematite and weak pervasive silicification is localized in the fault and indicates that the mineralization is likely associated with alkaline fluids. The Galer Lake fault is traced as an airborne magnetic lineament west of Holmes Township into Cairo and Powell townships (OGS 2004, 2000). Much of this area remains poorly explored and is an attractive exploration target in the author's opinion.

The McChesney gold showing is situated in northwest Flavelle Township in sheared syenite at the contact between the Cairo stock and alkalic metavolcanic rocks. Laminated quartz veins up to 10 m wide and 25 m long are boudinaged within a dextral shear zone that can be traced for more than 1000 m using airborne geophysical magnetic data (OGS 2004). Pods of pyrite, galena and sphalerite within the quartz veins contain high-grade gold assays (up to 20 g/t) but are too widely spaced to provide continuous tonnage. Weak pervasive carbonate, hematite, and sericite in the sheared syenite are accompanied by fluorite, tourmaline and rarely magnetite. There are several other dextral shear zones on the property that are subparallel to the main showing (*see* Photo 12) and each of these structures has the potential to be mineralized. A shear zone (locally named the Wiley Lake shear zone) is approximately 200 m south of the main showing and cuts Timiskaming assemblage metasedimentary and alkalic metavolcanic rocks. Old trenches on the shear zone encountered pervasive carbonate- and sericite-altered fine-grained wacke with various amounts of vein chlorite, pyrite and chalcopyrite and porphyroblasts of magnetite and tourmaline. Recent diamond drilling along this structure returned gold assays of 1.7 g/t over 14 m including a higher value of 4.1 g/t over 2.69 m (Brigadier Gold Limited press release dated December 20, 2004). As with other nearby shear zones the Wiley Lake structure can be traced by airborne geophysical data for over 2000 m southwest of the trenches and over 500 m to the northeast. Exploration is warranted along this structure especially to the northeast in the metavolcanic and metasedimentary rocks.

Gold assays are reported in several other places throughout the map area; however, mineralization is erratic and low grade. Powell and Hodgson (1992) documented Proterozoic tectonism that reactivated the LCDZ in the map area and speculated that Archean gold mineralization could be remobilized into the reactivated fault. In 2003 Winteroad Mineral Corporation held mining claims in the central part of Burt Township covering part of the Gowganda Formation over the inferred location of the LCDZ. Two diamond-drill holes attempted to penetrate the Gowganda Formation but failed to reach the underlying Archean rocks (D. Dawson, Insight Geophysics Incorporated, personal communication, 2004). However, a sericite and pyrite alteration zone in fractured, fine-grained pebbly wacke returned 500 ppb Au over 0.5 m over the projected extension of the LCDZ. Although not economic, the alteration zone is significant in that it indicates gold-bearing fluids were active during the Proterozoic. It is possible that gold was remobilized from the underlying Archean rocks and focussed into the reactivated LCDZ. The Winteroad diamond-drill holes encountered over 300 m vertical thickness of the Gowganda Formation; however, based on interpretation of geophysical data the Gowganda Formation is much thinner west of the Cross Lake fault (OGS 2004, 2000). Additionally, the inferred depth of the Gowganda Formation south of the trace of the LCDZ is much thinner than to the north which would have implications for selection of diamond-drill targets and directions. The potential for gold mineralization in the LCDZ under the Gowganda Formation is untested and use of recently published airborne geophysical data will greatly aid the search for areas where the Gowganda Formation is thin enough to be penetrated by diamond drilling.

## COPPER, NICKEL, PLATINUM AND PALLADIUM (PGEs)

The field mapping identified 3 geological environments that could potentially host copper-nickel-PGE mineralization. Large xenoliths of sulphide facies iron formation are included in komatiitic basalts in south Cairo Township (*see* Photo 1). This geology is analogous to geology that might host type IV mineralization of komatiite-associated Ni-Cu-PGE deposits (Lesher and Keays 2002). The komatiitic basalts in Cairo Township contain low MgO and are, therefore, most likely to be too low temperature to assimilate sulphur from the iron formation (cf. Lesher and Keays 2002). However, the ultramafic units extend west of the map area to Bannockburn Township where significant nickel mineralization is hosted in komatiites. Exploration along the entire extent of the komatiite horizon is warranted.

The mafic and ultramafic intrusive phases of the Otto stock are potential hosts for Cu-Ni-PGE mineralization. Outcrops of clinopyroxenite along Highway 11 in Eby Township contain various amounts of pyrite and malachite near the north contact of the Otto stock. A grab sample of this material collected by the author returned 6830 ppm Cu, 170 ppb Au, 164 ppb Pd and 55 ppb Pt (sample 01-BRB-019, Table 11, Appendix). Similar material collected by staff of the Resident Geologist's Office in Kirkland Lake returned up to 0.07 ounces of gold per ton (G. Grabowski, District Geologist, Personal communication 2002). The mafic and ultramafic phases of the Otto stock were previously mapped as greenstone roof pendants and migmatite, so their potential to host mineralization was not recognized. Any amount of sulphide mineralization in these phases should be sampled for their precious metal content.

A poorly exposed gabbroic intrusion underlies parts of Flavelle, Holmes, Burt and Gross townships. Outcrops in Flavelle Township contain coarse-grained pegmatitic gabbro, disseminated pyrite and local banding interpreted by the author as primary layering. Moore (1966) reported an assay of 0.53% copper from disseminated sulphide mineralization in this area. A grab sample of disseminated pyrite in gabbro collected by the author returned low metal values (Sample 03-BRB-647, Table 11). Airborne geophysical magnetic data suggests that layering is present especially in the northern, unexposed part of the intrusion and better exploration potential may exist in this area (OGS 2004).

## BASE METALS

Base metal exploration has been limited in the area; however, recent prospecting in northwest Burt Township uncovered disseminated sulphide mineralization and metamorphosed hydrothermal alteration. Disseminated and stringer pyrite hosted in altered intermediate metavolcanic rocks returned low metal values when assayed (samples 02-BRB-107, 123, Table 11). Distribution of the sulphide mineralization appears to be aerially restricted. However, the host rocks contain stockwork calc-silicate veins of epidote, chlorite and carbonate with various amounts of sericite and rare aluminosilicate in the matrix (*see* Photo 15). Whole rock geochemistry of this material displays sodium depletion and the author interprets this to indicate that the rocks are hydrothermally altered (sample 02-BRB-122, Table 11). Airborne geophysical surveys failed to detect any electromagnetic (EM) anomalies in this part of the map area and it is possible that any base metal mineralization is either deeply buried, zinc rich or widely disseminated (OGS 2000). The intermediate metavolcanic rocks in the north part of the map area are poorly exposed and previous work by Kresz (1992) and Jensen (1993) west of the map area indicate that these rocks are composed mainly of andesitic epiclastic and pyroclastic deposits with minor basalt and rhyolite flows and tuff. Geochemistry indicates that they are calc-alkalic and possibly related to the calc-alkalic rocks in Sheridan Township approximately 35 km northwest, where zinc mineralization is situated in the upper Tisdale assemblage (*see* Figure 6e, f; cf. Vaillancourt 1999). As geophysical methods are poor for detecting zinc-rich deposits geochemical exploration similar to the methods outlined by Hamilton et al. (2002) may be appropriate in the map area.

Base metal mineralization also occurs on the Todora property in central Eby Township. Disseminated, patchy and stringer chalcopyrite occurs in quartz veins and in carbonate-altered mafic metavolcanic rocks adjacent to a quartz-feldspar phyric intrusion. Historical records report copper assays from grab samples up to 13% and gold assays from diamond-drill holes up to 2.5 ounces of gold per ton but there are many discrepancies in the drill logs and reports that has tainted the property (assessment file KL2701 – Kirkland Lake Resident Geologist's Office). A single grab sample of chalcopyrite-rich mafic metavolcanic rocks collected by the author returned over 6000 ppm copper (sample 03-BRB-686, Table 11) indicating potential for copper mineralization in the area. The mineralization is located along the axial trace of a syncline and the mineralization may be structural rather than volcanogenic massive sulphide related; however, the area requires further work to evaluate the chalcopyrite mineralization.

## OTHER OCCURRENCES

### Barite

Barite veins commonly with purple fluorite occur in several localities near the Cairo stock. The largest vein is located on the southwest shore of Browning Lake in Cairo Township. The vein is up to 1.5 m wide and extends for approximately 30 m along a northwest-striking fracture in syenite of the Cairo stock. The vein was explored via an adit and several trenches and consists of coarsely crystalline white barite, quartz, purple fluorite and sparse sulphide mineralization including pyrite, galena and chalcopyrite. Weak hematite alteration accompanies the host syenite. Bulk samples from the vein could not be concentrated enough for commercial extraction and the vein was subsequently abandoned (R. Hill, Extender Minerals Ltd, personal communication, 2001). Barite veins were discovered in trenches at the Biralger copper-gold occurrence, northwest of Moyner Lake, west of Galer Lake and in the felsic pluton in north-central Holmes Township. None of these veins exceeds 1.5 m long by 0.2 m wide and most are just stringers in tension gashes or aligned parallel to the principle foliation. Sinclair (1982) inferred that the Browning Lake barite vein was Proterozoic based on lead isotope data from galena samples. This data is compatible with barite hosted in the Gowganda Formation in Yarrow Township approximately 15 km southwest of the map area (cf. Junnila 1990). However, the Cairo stock is alkalic and contains high barium that is likely to have been remobilized during intrusion and metamorphism. The author believes that some of the barite veins are Archean and that there must be 2 barite mineralization events in the map area.

### Diabase-Hosted Mineralization

The author examined a pit sunk in a diabase dike identified by Lovell (1967) that contained honey-coloured sphalerite in quartz-epidote veins with abundant pyrite and magnetite. A selected grab sample 02-BRB-132 (Table 11) returned over 55 000 ppm Zn, 3165 ppm Pb and 328 ppb Au. The northeast-striking diabase dike has similar geochemistry to diabase dikes with low magnetic susceptibility mapped in Eby and Otto townships that may be correlated with the Biscotasing dike swarm (cf. Osmani 1991; *see* Figure 17a, b, Table 11 – sample 03-BRB-160). The showing in Cairo Township appears to be isolated but it does suggest the potential for Proterozoic mineralization elsewhere in the region.

### Asbestos

Asbestos fibres were observed in peridotite in 2 places in the map area. Asbestos was observed in Cairo Township west of Highway 65 in strongly serpentinized peridotite. This occurrence has had limited diamond-drill testing in the 1950s but the showing was determined to be uneconomic at this time (Lovell

1967). Stringers of asbestos fibre up to 3 mm wide were observed in a peridotite in southwest Eby Township. The peridotite is isolated and its geological setting is poorly understood. It may be a cumulate-textured komatiite but is more likely to be an intrusion similar to the peridotite in Cairo Township.

### Sand and Gravel

Several sand and gravel pits occur in the area and some show signs of recent exploitation (summer 2004). Pits and excavations along the Watabeag road in Burt and Gross townships are sunk in eolian sand and glaciofluvial outwash deposits (cf. Baker 1985). These deposits hold the most promise for further development in the author's opinion. Pits in Cairo, Flavelle and Holmes townships are of limited extent and appeared to be used only for repair of local roads.

### Other

Disseminated and patchy chalcopyrite was observed in several outcrops of gabbro in south Cairo Township. A selected grab sample of this material returned 1288 ppm copper (Sample 02-GL-234, Table 11). The gabbro is part of a strongly magnetic mafic and ultramafic sill that intruded mafic metavolcanic rocks. Further exploration along this sill, especially in the St. Paul Lake area, may discover more economic mineralization.

Disseminated chalcopyrite was observed in foliated and hematite-altered quartz monzonite of the Round Lake Batholith along the Montreal River in south Cairo Township. Lovell (1967) indicated that the chalcopyrite was accompanied by pyrite, magnetite and quartz-carbonate veins at the contact of the felsic intrusion with gabbro and serpentinite. A grab sample of mineralized quartz monzonite collected by the field crew returned 2040 ppm copper (Sample 02-GL-247, Table 11). Although the mineralization appears to be restricted to the Round Lake batholith the mafic and ultramafic rocks may also host mineralization. Disseminated pyrite was observed in gabbro and significant portions of the intrusion are overburden covered such that mineralization may be present in these areas.

Zinc mineralization is reported in iron formation and interflow metasedimentary rocks in 2 parts of the map area. Stratabound sphalerite and pyrite mineralization is located in northwest Cairo Township approximately 500 m east of Narrow Lake. Trenching and diamond-drill testing returned over 33 000 ppm Zn and 2800 ppm lead in graphitic interflow metasedimentary rocks within mafic metavolcanic rocks (AFRI file 42A02SE0032). The interflow unit was narrow and of limited strike length which precluded further exploration.

Zinc and lead mineralization has been recently discovered in Flavelle Township and is associated with magnetite-chert iron formation (J. Rapski, Big Knot Timber Inc., personal communication, 2005). Stripping and trenching on airborne magnetic and electromagnetic geophysical data revealed galena and sphalerite mineralization in iron formation and a single grab sample of this material returned over 53% lead, 1% zinc and 72 g/t silver. Exploration is ongoing but this information strongly suggests that the entire strike length of the iron formation is prospective for similar type of mineralization.

## Recommendations for Mineral Exploration

The Highway 66 area is prospective for gold, base metal and copper-nickel-PGE mineralization. Past gold producers in Eby and Otto townships are situated along northeast-striking faults near the Larder Lake–

Cadillac deformation zone (LCDZ). Future gold exploration must be aware of this style of mineralization and search for possible gold-bearing structures at high angles to the main structural trends.

Gold is spatially associated the LCDZ and its several related splay faults. East of the Cross Lake fault gold is located in narrow intensely foliated faults within the LCDZ such as north of Vigrass Lake along Highway 66 in Otto Township. Green mica, pyrite, pervasive iron carbonate and weak sericite alteration accompany the gold and the presence and abundance of these minerals can be used as vectors to ore. The author notes that green mica-altered fault zones occur along the Blanche River in Eby Township and in the central part of Kenogami Lake. This latter fault zone is coincident with airborne magnetic geophysical lineament (OGS 2004) that extends under the Gowganda Formation west of the lake. To the author's knowledge this part of the fault has not been explored and it is recommended that any remotely sensed geophysical or geochemical anomaly in this area be diamond-drill tested. The vertical derivative products of the high-resolution Kirkland Lake airborne magnetic geophysical survey indicate that the fault zone underlying Kenogami Lake is the north branch of dextral strike-slip basin with the main trace of LCDZ defining the south branch. Maximum extension in this basin that is filled with Timiskaming alkalic metavolcanic and clastic metasedimentary rocks occurs under the Gowganda Formation and this area should be especially attractive for gold mineralization.

West of the Cross Lake fault gold is associated with the main trace of the LCDZ and several subparallel shear zones. Where the shear zones cut Timiskaming assemblage metavolcanic and metasedimentary rocks widespread carbonate and sericite alteration with pyrite, magnetite, minor base metal mineralization and gold is present as stringers and disseminations. Quartz veining is subsidiary and may not be present. Such widespread mineralization responds well to induced polarization (IP) surveys and successful exploration may discover large-tonnage low-grade deposits with smaller zones of high-grade mineralization (cf. Burden 2003). Zones of dilatancy are created where the shear zones cross the contact of the Cairo stock and large quartz veins are formed. These veins although commonly spectacular in size contain sporadic high-grade gold mineralization and are boudinaged in the shear zone. They, therefore, have limited tonnage potential. The quartz veins at the McChesney property in Flavelle Township is such an example. Other areas where zones of dilatancy may occur are approximately 200 m west of Galer Lake and approximately 700 m north of the McChesney quartz veins. Prospecting in these areas is recommended.

The Biralger copper-gold occurrence appears to be unique in the map area and the mineralization remains open along strike and down dip. Further testing of this prospect is recommended. In conjunction with this showing the author noted that mafic metavolcanic rocks were strongly altered in the LCDZ south of the showing and this alteration extended east until it disappeared under the Gowganda Formation in Middleton Lake. It is recommended that magnetic, electromagnetic and IP geophysical surveys be carried out over Middleton Lake and favourable responses should be diamond-drill tested. The LCDZ extends under a thin outlier of Gowganda Formation west of the Biralger occurrence in the area of Morrison Lake. Stripping and trenching of the Cairo stock from the Biralger showing to the Gowganda Formation revealed quartz veining, fluorite, hematite and sparse pyrite in sheared syenite, and exploration under the Gowganda Formation is recommended.

Powell and Hodgson (1992) documented Proterozoic deformation in the Gowganda Formation in Holmes and Burt townships over the trace of the LCDZ. These authors speculated that gold could be remobilized into the Gowganda Formation and may serve as an indication of better mineralization in the Archean basement. Exploration by Winteroad Mineral Corporation in central Burt Township encountered anomalous gold in a narrow sericite-pyrite alteration zone in the Gowganda Formation above the inferred location of the LCDZ. This indicates that there is potential for gold mineralization in the Archean basement and that there is potential all along the inferred extension of the LCDZ under the Proterozoic cover. The area identified by Powell and Hodgson (1992) in Holmes Township approximately 300 m north of Highway 66 is recommended as a likely target. Airborne magnetic geophysical data indicates that the Gowganda Formation is thinner west of the Cross Lake fault and should be easily penetrated by diamond drilling (OGS 2004).

The Consolidated Matachewan and Young–Davidson gold mines occur just west of the map area in Powell Township. Gold is hosted in syenite intrusions and mafic metavolcanic rocks at or near the unconformity with Timiskaming metasedimentary rocks. Exploration along this contact eastward into the map area with attention to looking for syenite intrusions is recommended. Exploration north of the known deposits in Powell Township discovered gold in deformed and altered ultramafic and mafic metavolcanic rocks (Oka zone). The mafic metavolcanic rocks extend into Cairo Township and appear to be terminated at the Montreal River fault. Ultramafic rocks were not observed in the map area; nevertheless, the area west of the Montreal River to Powell Township should be explored for gold.

Volcanogenic massive sulphide mineralization is unknown in the map area. However, disseminated and stringer chalcopyrite is located at the Todora occurrence in Eby Township and in gabbroic sills in Cairo Township. The potential for significant copper mineralization is largely unknown as both of these environments are under explored in the author's opinion. Disseminated and stringer sulphides accompanied by sericite, rare aluminosilicate and vein-style calc-silicate alteration occurs at the Bastarache showing in northwest Burt Township. Strong sodium depletion indicates that the host intermediate metavolcanic rocks experienced hydrothermal alteration. Recognition of base metal type alteration indicates that the entire package of intermediate metavolcanic rocks in the north part of the map area is prospective. If the intermediate metavolcanic rocks are similar to that hosting zinc mineralization in Sheridan Township (35 km northwest) then the entire package of rocks should be explored. As zinc-rich mineralization is less responsive to magnetic and electromagnetic geophysical methods mapping hydrothermal alteration and geochemical methods may be the preferred exploration methods in these rocks.

Zinc and lead mineralization occurs in a few areas throughout the map area. Mineralization associated with a diabase dike in Cairo Township appears to be Proterozoic and of limited aerial extent. Zinc and lead mineralization in northwest Cairo Township appears to be stratabound in graphitic interflow metasedimentary rocks and may be representative of a more extensive style of mineralization. Further exploration is recommended north and west of the map area. Lead and zinc mineralization is associated with magnetite-chert iron formation in Flavelle Township. The author has not seen this mineralization and assumes it is an exhalative product related to deposition of the iron formation. If this is true then the exploration along the iron formation should concentrate the thicker portions of the iron formation especially in close proximity to felsic metavolcanic rocks in Eby Township and intermediate volcaniclastic rocks in Flavelle Township. Mineralization may not necessarily be associated with the most magnetic portions of the iron formation and cross faults may also serve as hosts. Ground magnetic geophysical surveys and use of overburden geochemical methods may be useful techniques to help locate mineralization.

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# Appendix

## Geochemistry

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**Table 2.** Geochemistry of ultramafic metavolcanic and intrusive rocks - Highway 66 area.

| **Sample** | | **02-BRB-072** | **02-BRB-084** | **02-BRB-208** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 531920 | 528677 | 530453 |
| **Northing** | | 5311119 | 5310499 | 5311312 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo Twp. | Cairo Twp. | Cairo Twp. |
| **Rock Type** | | contaminated spinifex komatiite | peridotite | ultramafic metavolcanic flow |
| | **Det. Limit** | | | |
| SiO2 (wt. %) | | 51.07 | 40.39 | 41.48 |
| TiO2 | | 0.85 | 0.07 | 1.16 |
| Al2O3 | | 15.56 | 1.53 | 5.61 |
| Fe2O3 | | 11.65 | 6.08 | 15.14 |
| MnO | | 0.24 | 0.04 | 0.22 |
| MgO | | 6.35 | 38.45 | 19.89 |
| CaO | | 9.24 | 0.09 | 8.94 |
| Na2O3 | | 4.04 | 0.01 | 0.11 |
| K2O | | 0.32 | N.D. | 0.01 |
| P2O5 | | 0.05 | N.D. | 0.12 |
| LOI | | 1.46 | 12.34 | 7.06 |
| **total** | | **100.84** | **98.99** | **99.75** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 5094.9 | 419.58 | 6953.04 |
| Li | | 14 | N.D. | 16 |
| Be | 0.01 | N.D. | 0.15 | 1.8 |
| Sc | | 47.56 | 7.63 | 22.18 |
| V | | 307.63 | 25.56 | 170.67 |
| Cr | | 1112 | 1511 | 1848 |
| Co | 1 | 85.47 | 110.07 | 113.64 |
| Ni | 3 | 363 | 2339 | 1374 |
| Cu | 3 | 52 | N.D. | 336 |
| Zn | | 75 | 74 | 239 |
| Ga | | 16 | 2 | 9 |
| Rb | | 10.18 | 0.64 | 0.76 |
| Sr | | 100.40 | 4.20 | 34.50 |
| Y | | 14.62 | 0.86 | 20.52 |
| Zr | | 50.20 | 4.60 | 104.00 |
| As | 1 | 1.00 | N.D. | N.D. |
| Ag | | 2.00 | N.D. | 2.00 |
| Nb | | 1.60 | N.D. | 11.00 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | | |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 0.29 | 0.40 | 0.19 |
| Ba | | 120.00 | N.D. | N.D. |
| Hf | | 1.50 | 0.10 | 2.90 |
| Ta | | 0.28 | 0.18 | 0.87 |
| W | | 26.00 | 25.00 | 18.00 |

| | **Det. Limit** | **02-BRB-072** continued | **02-BRB-084** continued | **02-BRB-208** continued |
|---|---|---|---|---|
| Pb | 3 | N.D. | N.D. | N.D. |
| Th | | 0.18 | N.D. | 2.92 |
| U | | 0.06 | 0.02 | 0.76 |
| La | | 1.89 | 0.26 | 8.79 |
| Ce | | 4.93 | 0.50 | 24.31 |
| Pr | | 0.82 | 0.07 | 3.75 |
| Nd | | 4.18 | 0.35 | 16.57 |
| Sm | | 1.56 | 0.11 | 4.20 |
| Eu | | 0.64 | 0.07 | 1.24 |
| Gd | | 2.26 | 0.19 | 4.45 |
| Tb | | 0.46 | 0.04 | 0.72 |
| Dy | | 2.73 | 0.17 | 3.86 |
| Ho | | 0.61 | 0.04 | 0.82 |
| Er | | 1.73 | 0.11 | 2.05 |
| Tm | | 0.32 | 0.04 | 0.30 |
| Yb | | 1.74 | 0.13 | 1.63 |
| Lu | | 0.29 | 0.03 | 0.27 |
| Au (ppb) | 6 | | | |
| Pd | 2 | | | |
| Pt | 1 | | | |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants
N.M. = not measured
N.D. = not detected

**Table 2**. Geochemistry of ultramafic metavolcanic and intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **02-BRB-239** | **02-BRB-243** | **JAA-00-255** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 532392 | 532101 | 528841 |
| **Northing** | | 5311116 | 5311018 | 5321618 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo Twp. | Cairo Twp. | IR 72 |
| **Rock Type** | | komatiite/mafic flow | mafic flow/komatiite | ultramafic cumulate |
| | **Det. Limit** | | | |
| SiO2 (wt. %) | | 49.22 | 50.22 | 45.96 |
| TiO2 | | 0.72 | 0.77 | 1.14 |
| Al2O3 | | 12.48 | 13.16 | 7.05 |
| Fe2O3 | | 12.77 | 12.54 | 14.37 |
| MnO | | 0.19 | 0.2 | 0.18 |
| MgO | | 8.76 | 8.63 | 18.85 |
| CaO | | 10.26 | 8.34 | 7.66 |
| Na2O3 | | 3.38 | 3.91 | 1.04 |
| K2O | | 0.16 | 0.13 | 0.47 |
| P2O5 | | 0.04 | 0.05 | 0.12 |
| LOI | | 1.54 | 1.95 | 3.9 |
| **total** | | **99.52** | **99.9** | **100.74** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 4315.68 | 4615.38 | 6833.16 |
| Li | | 16 | 20 | 31.01 |
| Be | 0.01 | 0.13 | 0.1 | N.D. |
| Sc | | 36.06 | 37.73 | 15 |
| V | | 228.42 | 236.52 | 172 |
| Cr | | 503 | 473 | >500.00 |
| Co | 1 | 58.42 | 58.29 | 88.94 |
| Ni | 3 | 101 | 88 | 1101.97 |
| Cu | 3 | 73 | 75 | 174.36 |
| Zn | | 88 | 102 | 85.04 |
| Ga | | 14 | 14 | 11.31 |
| Rb | | 3.23 | 1.07 | 28.62 |
| Sr | | 181.40 | 51.60 | 67 |
| Y | | 14.99 | 14.32 | 19.43 |
| Zr | | 39.40 | 41.50 | 110.68 |
| As | 1 | N.D. | N.D. | 3.9 |
| Ag | | 2.00 | 2.00 | N.M. |
| Nb | | 1.30 | 1.40 | 10.68 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | | N.D. |
| Sn | | N.D. | N.D. | 1.25 |
| Cs | | 0.29 | 0.16 | >5.00 |
| Ba | | N.D. | 35.00 | 67.28 |
| Hf | | 1.20 | 1.30 | 3.55 |
| Ta | | 0.26 | 0.30 | 0.78 |
| W | | N.D. | N.D. | 0.3 |

| | | **02-BRB-239** | **02-BRB-243** | **JAA-00-255** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | N.D. | 2.44 |
| Th | | 0.16 | 0.21 | 4.97 |
| U | | 0.05 | 0.07 | 1.29 |
| La | | 2.14 | 2.47 | 22.54 |
| Ce | | 5.56 | 6.68 | 45.62 |
| Pr | | 0.94 | 1.06 | 5.64 |
| Nd | | 4.84 | 5.04 | 22.82 |
| Sm | | 1.67 | 1.70 | 4.86 |
| Eu | | 0.67 | 0.73 | 1.27 |
| Gd | | 2.29 | 2.52 | 4.57 |
| Tb | | 0.46 | 0.47 | 0.66 |
| Dy | | 2.93 | 2.84 | 3.82 |
| Ho | | 0.65 | 0.68 | 0.77 |
| Er | | 1.92 | 1.85 | 1.97 |
| Tm | | 0.27 | 0.29 | 0.28 |
| Yb | | 1.64 | 1.89 | 1.77 |
| Lu | | 0.27 | 0.30 | 0.27 |
| Au (ppb) | 6 | | | N.D. |
| Pd | 2 | | | N.D. |
| Pt | 1 | | | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants
N.M. = not measured
N.D. = not detected

**Table 2.** Geochemistry of ultramafic metavolcanic and intrusive rocks - Highway 66 area (cont'd).

| Sample | Det. Limit | 03-BRB-189 | 03-BRB-198 | 03-BRB-199 |
|---|---|---|---|---|
| Easting (Zone 17) | | 561958 | 566791 | 566791 |
| Northing | | 5321000 | 5327039 | 5327039 |
| Datum | | NAD 83 | NAD 83 | NAD 83 |
| Township | | Eby Twp | Otto Twp | Otto Twp |
| Rock Type | | peridotite | spinifex UM flow | pillowed flow |
| SiO2 (wt. %) | | 38.11 | 48.93 | 49.33 |
| TiO2 | | 0.14 | 0.61 | 0.59 |
| Al2O3 | | 3.77 | 11.81 | 11.17 |
| Fe2O3 | | 12.07 | 11.92 | 11.34 |
| MnO | | 0.17 | 0.16 | 0.17 |
| MgO | | 32.68 | 12.49 | 13.15 |
| CaO | | 2.41 | 7.96 | 7.58 |
| Na2O3 | | < 0.01 | 2.28 | 2.44 |
| K2O | | 0.01 | 0.10 | 0.03 |
| P2O5 | | 0.02 | 0.05 | 0.05 |
| LOI | | 10.30 | 3.21 | 4.00 |
| **total** | | **99.68** | **99.52** | **99.85** |
| CO2 | 0.03 | 0.35 | 0.25 | 0.81 |
| S | 0.01 | N.D. | 0.01 | 0.01 |
| Ti (ppm) | | 839.16 | 3656.34 | 3536.46 |
| Li | | N.D. | 32 | 23 |
| Be | 0.01 | N.D. | 0.19 | 0.16 |
| Sc | | 10.4 | 26.2 | 25.1 |
| V | | 62.8 | 190.1 | 181.7 |
| Cr | | 3791 | 1044 | 1235 |
| Co | 1 | 110 | 51 | 55 |
| Ni | 3 | 1097 | 208 | 264 |
| Cu | 3 | 20 | 23 | 39 |
| Zn | | 79 | 75 | 71 |
| Ga | | 6 | 14 | 13 |
| Rb | | N.D. | N.D. | N.D. |
| Sr | | 5 | 52 | 21 |
| Y | | 3 | 15 | 15 |
| Zr | | 10 | 46 | 48 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | N.D. | 2 | N.D. |
| Nb | | N.D. | 1.5 | 1.5 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | | |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 0.488 | 0.107 | 0.135 |
| Ba | | N.D. | 48 | N.D. |
| Hf | | 0.2 | 1.3 | 1.3 |
| Ta | | N.D. | N.D. | N.D. |
| W | | N.D. | N.D. | N.D. |
| Pb | 3 | N.D. | N.D. | N.D. |
| Th | | N.D. | 0.26 | 0.25 |
| U | | N.D. | 0.071 | 0.071 |
| La | | 0.22 | 2.75 | 2.43 |
| Ce | | 0.64 | 6.75 | 6 |
| Pr | | 0.114 | 0.969 | 0.873 |
| Nd | | 0.62 | 4.92 | 4.38 |
| Sm | | 0.24 | 1.55 | 1.44 |
| Eu | | 0.114 | 0.548 | 0.609 |
| Gd | | 0.415 | 2.24 | 2.082 |
| Tb | | 0.078 | 0.405 | 0.383 |
| Dy | | 0.583 | 2.712 | 2.59 |
| Ho | | 0.135 | 0.597 | 0.57 |
| Er | | 0.407 | 1.792 | 1.683 |
| Tm | | 0.061 | 0.26 | 0.25 |
| Yb | | 0.42 | 1.7 | 1.62 |
| Lu | | 0.067 | 0.256 | 0.24 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | 2.67 | 8.87 | 8.03 |
| Pt | 1 | 4.69 | 9.9 | 8.96 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants
N.M. = not measured
N.D. = not detected

**Table 2.** Geochemistry of ultramafic metavolcanic and intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **03-BRB-536** | **03-BRB-569** | **03-BRB-570** | **03-BRB-572** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 565619 | 567034 | 567234 | 566784 |
| **Northing** | | 5326337 | 5327627 | 5327405 | 5327714 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | |
| **Township** | | Otto Twp | Otto Twp | Otto Twp | Otto Twp |
| **Rock Type** | | spinifex UM flow | massive ultramafic flow | massive ultramafic flow | massive ultramafic flow |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 49.21 | 49.16 | 43.04 | 44.18 |
| TiO2 | | 0.64 | 0.55 | 0.42 | 0.50 |
| Al2O3 | | 12.47 | 10.75 | 9.17 | 9.48 |
| Fe2O3 | | 11.31 | 10.74 | 11.90 | 11.76 |
| MnO | | 0.18 | 0.17 | 0.20 | 0.17 |
| MgO | | 9.96 | 14.39 | 20.74 | 19.37 |
| CaO | | 11.28 | 7.59 | 7.72 | 7.55 |
| Na2O3 | | 1.23 | 2.37 | 0.06 | 0.48 |
| K2O | | 0.94 | 0.05 | 0.03 | 0.03 |
| P2O5 | | 0.05 | 0.05 | 0.03 | 0.03 |
| LOI | | 2.04 | 3.22 | 5.91 | 5.52 |
| **total** | | **99.31** | **99.04** | **99.22** | **99.07** |
| CO2 | 0.03 | 0.27 | 0.14 | 0.25 | 0.22 |
| S | 0.01 | 0.01 | 0.03 | N.D. | N.D. |
| Ti (ppm) | | 3836.16 | 3296.7 | 2517.48 | 2997 |
| Li | | 13 | 36 | 8 | 43 |
| Be | 0.01 | 0.21 | 0.16 | 0.15 | 0.11 |
| Sc | | 27.1 | 28.5 | 22.1 | 19.5 |
| V | | 191.9 | 191.5 | 131.7 | 141.2 |
| Cr | | 884 | 1703 | 3186 | 2260 |
| Co | 1 | 46 | 70 | 66 | 67 |
| Ni | 3 | 159 | 400 | 506 | 662 |
| Cu | 3 | 181 | 49 | 13 | 10 |
| Zn | | 83 | 82 | 69 | 70 |
| Ga | | 18 | 11 | 10 | 11 |
| Rb | | 29 | 0.76 | N.D. | N.D. |
| Sr | | 134 | 19.9 | 47 | 25 |
| Y | | 14 | 14.04 | 10 | 9 |
| Zr | | 39 | 40.4 | 32 | 31 |
| As | 1 | N.D. | N.D. | N.D. | N.D. |
| Ag | | 3 | N.D. | N.D. | N.D. |
| Nb | | 1.5 | 1.3 | 0.9 | 0.8 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | | N.D. | | |
| Sn | | N.D. | | N.D. | N.D. |
| Cs | | 0.663 | 0.433 | 0.135 | 0.695 |
| Ba | | 163 | 27 | 32 | 39 |
| Hf | | 1.2 | 1.2 | 0.9 | 0.8 |
| Ta | | N.D. | N.D. | N.D. | N.D. |
| W | | N.D. | N.D. | N.D. | N.D. |

| | | **03-BRB-536** cont'd | **03-BRB-569** cont'd | **03-BRB-570** cont'd | **03-BRB-572** cont'd |
|---|---|---|---|---|---|
| | **Det. Limit** | | | | |
| Pb | 3 | 7 | N.D. | N.D. | N.D. |
| Th | | 0.2 | 0.24 | 0.18 | 0.08 |
| U | | 0.063 | 0.063 | 0.051 | 0.023 |
| La | | 2.5 | 2.42 | 1.57 | 1.01 |
| Ce | | 6.43 | 5.71 | 3.76 | 2.81 |
| Pr | | 1 | 0.815 | 0.574 | 0.45 |
| Nd | | 4.96 | 4.04 | 3.12 | 2.5 |
| Sm | | 1.59 | 1.4 | 1.08 | 0.89 |
| Eu | | 0.75 | 0.523 | 0.412 | 0.391 |
| Gd | | 2.178 | 2.022 | 1.51 | 1.351 |
| Tb | | 0.389 | 0.365 | 0.282 | 0.247 |
| Dy | | 2.576 | 2.444 | 1.869 | 1.7 |
| Ho | | 0.56 | 0.535 | 0.417 | 0.373 |
| Er | | 1.652 | 1.613 | 1.264 | 1.113 |
| Tm | | 0.244 | 0.234 | 0.184 | 0.163 |
| Yb | | 1.58 | 1.52 | 1.2 | 1.07 |
| Lu | | 0.239 | 0.239 | 0.179 | 0.163 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. | N.D. |
| Pd | 2 | 9.5 | N.D. | 3.18 | N.D. |
| Pt | 1 | 11.29 | 2.43 | 3.47 | 1.77 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area.

| **Sample** | **Det. Limit** | **02-BRB-046** | **02-BRB-080** | **02-BRB-090** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 543400 | 528466 | 526078 |
| **Northing** | | 5318772 | 5309293 | 5316263 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Holmes | Cairo | Cairo |
| **Rock Type** | | mafic amphibolite | hornfelsic basalt | massive mafic flow |
| SiO2 (wt.%) | | 47.72 | 50.15 | 52.45 |
| TiO2 | | 1.68 | 1.32 | 1.69 |
| Al2O3 | | 13.25 | 15.18 | 13.09 |
| Fe2O3 | | 16.25 | 14.89 | 18.46 |
| MnO | | 0.20 | 0.24 | 0.28 |
| MgO | | 5.70 | 3.28 | 2.47 |
| CaO | | 10.26 | 11.84 | 6.65 |
| Na2O3 | | 2.01 | 1.5 | 2.3 |
| K2O | | 0.13 | 0.32 | 0.24 |
| P2O5 | | 0.21 | 0.1 | 0.58 |
| LOI | | 2.19 | 0.78 | 2.39 |
| **total** | | **99.60** | **99.6** | **100.6** |
| CO2 | 0.03 | 0.22 | N.M. | N.M. |
| S | 0.01 | 0.12 | N.M. | N.M. |
| Ti (ppm) | | 10069.92 | 7912.08 | 10129.86 |
| Li | | 12 | 12 | 20 |
| Be | 0.01 | 0.4 | 0.2 | 0.71 |
| Sc | | 38.4 | 42.35 | 32.91 |
| V | | >320.0 | >320.00 | 19.94 |
| Cr | | 86 | 117 | N.D. |
| Co | 1 | 45 | 65.88 | 41.82 |
| Ni | 3 | 36 | 74 | 27 |
| Cu | 3 | 152 | 91 | 37 |
| Zn | | 161 | 120 | 192 |
| Ga | | 22 | 19 | 24 |
| Rb | | 4.55 | 10.73 | 10.1 |
| Sr | | 227 | 132.70 | 140.60 |
| Y | | 31.3 | 29.85 | 62.76 |
| Zr | | 80 | 85.40 | 156.80 |
| As | 1 | N.D. | 4.00 | 1.00 |
| Ag | | 3 | 2.00 | 2.00 |
| Nb | | 5.7 | 3.60 | 7.80 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | | N.D. | N.D. |
| Cs | | 0.166 | 0.33 | 9.72 |
| Ba | | 47 | 97.00 | 41.00 |
| Hf | | 2.2 | 2.50 | 4.70 |
| Ta | | 0.4 | 0.41 | 0.64 |
| W | | N.D. | 25.00 | 27.00 |
| | | continued | continued | continued |
| Pb | 3 | 7 | N.D. | N.D. |
| Th | | 0.75 | 0.47 | 0.75 |
| U | | 0.172 | 0.11 | 0.24 |
| La | | 10.89 | 5.51 | 12.20 |
| Ce | | 27.3 | 14.42 | 32.14 |
| Pr | | 4.025 | 2.28 | 5.49 |
| Nd | | 19.25 | 10.88 | 27.54 |
| Sm | | 4.89 | 3.34 | 8.74 |
| Eu | | 1.525 | 1.09 | 3.16 |
| Gd | | 5.556 | 4.64 | 12.02 |
| Tb | | 0.916 | 0.88 | 2.09 |
| Dy | | 5.672 | 5.69 | 12.68 |
| Ho | | 1.215 | 1.26 | 2.81 |
| Er | | 3.527 | 3.79 | 7.82 |
| Tm | | 0.52 | 0.58 | 1.21 |
| Yb | | 3.32 | 3.55 | 7.15 |
| Lu | | 0.511 | 0.61 | 1.16 |
| Au (ppb) | 6 | N.D. | N.M. | N.M. |
| Pd | 2 | N.D. | N.M. | N.M. |
| Pt | 1 | 2 | N.M. | N.M. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **02-BRB-091** | **02-BRB-114** | **02-BRB-202** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 525153 | 531632 | 527475 |
| **Northing** | | 5317103 | 5310100 | 5318043 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Powell | Cairo | Cairo |
| **Rock Type** | | massive mafic flow | mafic amphibolite | amphibolitic mafic flow |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 49.72 | 48.25 | 53.66 |
| TiO2 | | 1.24 | 1.7 | 1.41 |
| Al2O3 | | 15 | 15.02 | 15.94 |
| Fe2O3 | | 12.72 | 17.33 | 8.11 |
| MnO | | 0.2 | 0.24 | 0.15 |
| MgO | | 6.13 | 5.86 | 3.56 |
| CaO | | 10.35 | 8.93 | 9.1 |
| Na2O3 | | 1.8 | 2.63 | 5.74 |
| K2O | | 0.61 | 0.15 | 0.53 |
| P2O5 | | 0.08 | 0.14 | 0.08 |
| LOI | | 2.45 | 0.82 | 0.68 |
| **total** | | **100.31** | **101.08** | **98.96** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 7432.56 | 10189.8 | 8451.54 |
| Li | | 33 | 17 | 13 |
| Be | 0.01 | 0.16 | 0.28 | 0.3 |
| Sc | | 43.81 | 40.03 | 42.41 |
| V | | >320.00 | >320.00 | >320.00 |
| Cr | | 172 | 118 | 106 |
| Co | 1 | 64.95 | 74.65 | 52.76 |
| Ni | 3 | 118 | 94 | 82 |
| Cu | 3 | 104 | 99 | 110 |
| Zn | | 93 | 142 | 42 |
| Ga | | 16 | 19 | 18 |
| Rb | | 24.77 | 4.43 | 18.1 |
| Sr | | 117.00 | 241.10 | 231.00 |
| Y | | 23.03 | 35.60 | 20.94 |
| Zr | | 60.40 | 108.70 | 57.50 |
| As | 1 | 9.00 | N.D. | N.D. |
| Ag | | 2.00 | 2.00 | 2.00 |
| Nb | | 2.50 | 4.60 | 2.40 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | 5.00 | N.D. |
| Cs | | 1.36 | 0.18 | 1.31 |
| Ba | | 115.00 | N.D. | 233.00 |
| Hf | | 2.00 | 3.10 | 1.70 |
| Ta | | 0.33 | 0.43 | 0.34 |
| W | | 24.00 | 19.00 | 21.00 |

| | | **02-BRB-091** | **02-BRB-114** | **02-BRB-202** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | N.D. | 7.00 |
| Th | | 0.28 | 0.61 | 0.25 |
| U | | 0.10 | 0.16 | 0.10 |
| La | | 3.76 | 6.51 | 2.97 |
| Ce | | 9.78 | 17.55 | 8.53 |
| Pr | | 1.68 | 2.89 | 1.47 |
| Nd | | 8.20 | 14.23 | 7.40 |
| Sm | | 2.67 | 4.36 | 2.39 |
| Eu | | 1.02 | 1.46 | 1.12 |
| Gd | | 3.66 | 5.76 | 3.29 |
| Tb | | 0.70 | 1.07 | 0.64 |
| Dy | | 4.18 | 6.63 | 3.76 |
| Ho | | 0.97 | 1.55 | 0.84 |
| Er | | 2.81 | 4.35 | 2.44 |
| Tm | | 0.45 | 0.69 | 0.37 |
| Yb | | 2.76 | 4.14 | 2.26 |
| Lu | | 0.43 | 0.70 | 0.37 |
| Au (ppb) | 6 | N.M. | N.M. | N.M. |
| Pd | 2 | N.M. | N.M. | N.M. |
| Pt | 1 | N.M. | N.M. | N.M. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | **Det. Limit** | **02-BRB-238** | **JAA-00-139** | **JAA-00-140** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 532728 | 523560 | 559822 |
| **Northing** | | 5311953 | 5310021 | 5323128 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Eby | Eby |
| **Rock Type** | | mafic flow/intrusion | Mafic Volcanic | Mafic Volcanic |
| SiO2 (wt.%) | | 49.3 | 50.07 | 48.49 |
| TiO2 | | 1.01 | 1.29 | 1.2 |
| Al2O3 | | 14.42 | 14.77 | 14.53 |
| Fe2O3 | | 13.55 | 15.2 | 15.39 |
| MnO | | 0.21 | 0.16 | 0.23 |
| MgO | | 6.64 | 6.49 | 6.62 |
| CaO | | 7.98 | 4.27 | 8.04 |
| Na2O3 | | 3.85 | 2.33 | 2.89 |
| K2O | | 0.84 | 0.59 | 0.83 |
| P2O5 | | 0.07 | 0.1 | 0.09 |
| LOI | | 1.83 | 5.51 | 2.28 |
| **total** | | **99.7** | **100.78** | **100.59** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 6053.94 | 7732.26 | 7192.8 |
| Li | | 16 | 37.35 | 14.52 |
| Be | 0.01 | 0.34 | N.D. | N.D. |
| Sc | | 39.33 | 36 | 39 |
| V | | 266.91 | 298 | 330 |
| Cr | | 262 | 99.49 | 115.75 |
| Co | 1 | 53.4 | 44.89 | 46.83 |
| Ni | 3 | 91 | 94.09 | 66.52 |
| Cu | 3 | 53 | 160.65 | 93.32 |
| Zn | | 128 | 91.65 | 107.02 |
| Ga | | 17 | 15.69 | 17.21 |
| Rb | | 25.06 | 23.27 | 14.88 |
| Sr | | 290.60 | 78 | 162 |
| Y | | 23.53 | 25.23 | 27.16 |
| Zr | | 65.70 | 72.24 | 70.31 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | 2.00 | N.M. | N.M. |
| Nb | | 2.90 | 3.28 | 3.02 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | N.D. | N.D. |
| Sn | | N.D. | 0.52 | 0.79 |
| Cs | | 0.83 | 0.75 | 0.22 |
| Ba | | 178.00 | 60.24 | 284.96 |
| Hf | | 2.00 | 2.17 | 2.25 |
| Ta | | 0.34 | 0.58 | 0.58 |
| W | | N.D. | 0.34 | 0.23 |
| | | continued | continued | continued |
| Pb | 3 | 6.00 | 2.13 | 1.86 |
| Th | | 0.34 | 0.41 | 0.34 |
| U | | 0.14 | 0.11 | 0.08 |
| La | | 3.97 | 7.33 | 4.28 |
| Ce | | 10.61 | 14.22 | 10.94 |
| Pr | | 1.71 | 2.24 | 1.73 |
| Nd | | 8.17 | 10.12 | 8.88 |
| Sm | | 2.73 | 2.79 | 2.69 |
| Eu | | 1.03 | 0.88 | 0.91 |
| Gd | | 3.41 | 3.44 | 3.46 |
| Tb | | 0.70 | 0.61 | 0.65 |
| Dy | | 4.34 | 4 | 4.33 |
| Ho | | 0.99 | 0.95 | 1.03 |
| Er | | 2.90 | 2.83 | 3.03 |
| Tm | | 0.45 | 0.42 | 0.45 |
| Yb | | 2.87 | 2.83 | 3.02 |
| Lu | | 0.48 | 0.45 | 0.49 |
| Au (ppb) | 6 | N.M. | N.D. | N.D. |
| Pd | 2 | N.M. | N.D. | N.D. |
| Pt | 1 | N.M. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **JAA-00-197** | **JAA-00-198** | **JAA-00-199** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 557718 | 554960 | 553106 |
| **Northing** | | 5324029 | 5323648 | 5323575 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Eby | Eby | Burt |
| **Rock Type** | | Mafic Volcanic | Pillowed Mafic Volcanic | Mafic Volcanic |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 47.92 | 51.05 | 47.45 |
| TiO2 | | 1.92 | 1.82 | 2.02 |
| Al2O3 | | 13.65 | 13.04 | 13.69 |
| Fe2O3 | | 19.07 | 17.03 | 17.74 |
| MnO | | 0.24 | 0.26 | 0.22 |
| MgO | | 4.8 | 3.75 | 5.39 |
| CaO | | 8.14 | 6.94 | 9.38 |
| Na2O3 | | 1.65 | 1.98 | 1.51 |
| K2O | | 0.14 | 0.24 | 0.07 |
| P2O5 | | 0.16 | 0.16 | 0.18 |
| LOI | | 3.07 | 4.3 | 2.88 |
| **total** | | **100.76** | **100.57** | **100.53** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 11508.48 | 10909.08 | 12107.88 |
| Li | | 13.45 | 8.23 | 11.13 |
| Be | 0.01 | N.D. | N.D. | N.D. |
| Sc | | 38 | 37 | 39 |
| V | | 358 | 368 | 406 |
| Cr | | 12.91 | 15.22 | 82.26 |
| Co | 1 | 42.03 | 44.18 | 44.71 |
| Ni | 3 | 24.8 | 22.04 | 56.29 |
| Cu | 3 | 98.18 | 99.83 | 101.21 |
| Zn | | 113.12 | 116.26 | 111.5 |
| Ga | | 18.93 | 18.78 | 18.51 |
| Rb | | 2.48 | 7.21 | 1.17 |
| Sr | | 116 | 149 | 171 |
| Y | | 43.88 | 40.69 | 39.52 |
| Zr | | 116.63 | 113.01 | 107.67 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | N.M. | N.M. | N.M. |
| Nb | | 5.66 | 5.42 | 5.68 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | 0.85 | 0.94 | 0.84 |
| Cs | | 0.36 | >5.00 | 0.17 |
| Ba | | 43.5 | 17.67 | 27 |
| Hf | | 3.78 | 3.74 | 3.49 |
| Ta | | 0.46 | 0.43 | 0.45 |
| W | | 0.26 | 0.27 | 0.23 |

| | | **JAA-00-197** | **JAA-00-198** | **JAA-00-199** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | 4.96 | 1.8 | 2.34 |
| Th | | 0.73 | 0.66 | 0.73 |
| U | | 0.2 | 0.18 | 0.2 |
| La | | 8.05 | 7.35 | 8.69 |
| Ce | | 20.7 | 19.18 | 21.68 |
| Pr | | 3.17 | 2.95 | 3.23 |
| Nd | | 15.64 | 14.89 | 15.78 |
| Sm | | 4.76 | 4.57 | 4.62 |
| Eu | | 1.43 | 1.46 | 1.48 |
| Gd | | 6.14 | 5.8 | 5.77 |
| Tb | | 1.06 | 1.02 | 0.97 |
| Dy | | 6.97 | 6.51 | 6.52 |
| Ho | | 1.62 | 1.5 | 1.48 |
| Er | | 4.67 | 4.27 | 4.33 |
| Tm | | 0.7 | 0.64 | 0.63 |
| Yb | | 4.5 | 4.1 | 4.18 |
| Lu | | 0.73 | 0.64 | 0.67 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **JAA-00-203** | **JAA-00-261** | **JAA-00-279** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 560626 | 535357 | 570015 |
| **Northing** | | 5326732 | 5314914 | 5327120 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Eby | Flavelle | Otto |
| **Rock Type** | | Mafic Volcanic | Mafic Volcanic | Deformed Pillowed Mafic Volcanic |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 48.98 | 50.16 | 49.26 |
| TiO2 | | 1.24 | 1.36 | 0.82 |
| Al2O3 | | 13.96 | 14.68 | 14.07 |
| Fe2O3 | | 12.9 | 16.79 | 12.4 |
| MnO | | 0.29 | 0.19 | 0.25 |
| MgO | | 4.65 | 5.78 | 8.03 |
| CaO | | 7.32 | 2.63 | 9.82 |
| Na2O3 | | 2.51 | 3.45 | 1.79 |
| K2O | | 0.63 | 0.9 | 0.73 |
| P2O5 | | 0.09 | 0.08 | 0.06 |
| LOI | | 7.63 | 4.65 | 2.66 |
| **total** | | **100.2** | **100.67** | **99.89** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 7432.56 | 8151.84 | 4915.08 |
| Li | | 26.83 | 62.54 | |
| Be | 0.01 | N.D. | 4 | N.D. |
| Sc | | 36 | 36 | 35 |
| V | | 289 | 349 | 257 |
| Cr | | 100.73 | 133.11 | |
| Co | 1 | 40.04 | 60.1 | |
| Ni | 3 | 69.77 | 104.79 | |
| Cu | 3 | 92.07 | 3.55 | |
| Zn | | 81.11 | 143.89 | |
| Ga | | 14.3 | 18.04 | |
| Rb | | 19.11 | 66.67 | 19.76 |
| Sr | | 83 | 78 | 140 |
| Y | | 30.08 | 33.26 | 25.38 |
| Zr | | 65.67 | 48.22 | 55.18 |
| As | 1 | N.D. | N.D. | 5.28 |
| Ag | | N.M. | N.M. | |
| Nb | | 3.12 | 2.23 | 2.69 |
| Mo | <1 | N.D. | 3.61 | |
| Cd | | N.D. | N.D. | |
| Sn | | 0.67 | 0.72 | |
| Cs | | 0.58 | >5.00 | 0.19 |
| Ba | | 210.06 | 319.36 | |
| Hf | | 2.24 | 1.69 | 1.87 |
| Ta | | N.D. | N.D. | N.D. |
| W | | 0.41 | 1.58 | |

| | | **JAA-00-203** | **JAA-00-261** | **JAA-00-279** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | 1.51 | 2.64 | |
| Th | | 0.36 | 0.29 | 0.37 |
| U | | 0.1 | 0.44 | 0.1 |
| La | | 4.27 | 7.18 | 6.06 |
| Ce | | 11.34 | 14.95 | 12.68 |
| Pr | | 1.79 | 1.83 | 2 |
| Nd | | 9.44 | 8.9 | 9.34 |
| Sm | | 3.03 | 2.96 | 2.54 |
| Eu | | 1.05 | 1.28 | 1.05 |
| Gd | | 3.98 | 4.03 | 3.38 |
| Tb | | 0.7 | 0.73 | 0.6 |
| Dy | | 4.65 | 4.98 | 4.04 |
| Ho | | 1.08 | 1.15 | 0.93 |
| Er | | 3.18 | 3.37 | 2.83 |
| Tm | | 0.47 | 0.54 | 0.39 |
| Yb | | 3.08 | 3.21 | 2.64 |
| Lu | | 0.5 | 0.49 | 0.42 |
| Au (ppb) | 6 | N.D. | 9.72 | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | Det. Limit | **03-BRB-159** | **03-BRB-172** | **03-BRB-175** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 529164 | 552833 | 558124 |
| **Northing** | | 5310969 | 5323779 | 5323410 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Burt | Eby |
| **Rock Type** | | mafic flow | massive mafic flow | mafic flow |
| SiO2 (wt.%) | | 52.02 | 49.06 | 49.37 |
| TiO2 | | 0.78 | 1.75 | 0.73 |
| Al2O3 | | 13.56 | 12.65 | 14.21 |
| Fe2O3 | | 11.92 | 16.75 | 13.64 |
| MnO | | 0.33 | 0.27 | 0.19 |
| MgO | | 7.36 | 4.89 | 6.94 |
| CaO | | 7.00 | 7.44 | 9.64 |
| Na2O3 | | 4.12 | 2.31 | 2.35 |
| K2O | | 0.13 | 0.31 | 0.09 |
| P2O5 | | 0.07 | 0.17 | 0.06 |
| LOI | | 2.36 | 3.48 | 2.31 |
| **total** | | **99.65** | **99.08** | **99.53** |
| CO2 | 0.03 | 0.26 | 0.84 | 0.18 |
| S | 0.01 | N.D. | 0.04 | 0.03 |
| Ti (ppm) | | 4675.32 | 10489.5 | 4375.62 |
| Li | | 17 | 15 | 13 |
| Be | 0.01 | 0.28 | 0.44 | 0.25 |
| Sc | | 30.6 | 30.3 | 33.5 |
| V | | 226.4 | >320.0 | 238.7 |
| Cr | | 73 | 112 | 152 |
| Co | 1 | 44 | 37 | 47 |
| Ni | 3 | 67 | 60 | 70 |
| Cu | 3 | 40 | 66 | 100 |
| Zn | | 158 | 160 | 87 |
| Ga | | 16 | 19 | 16 |
| Rb | | 3 | 10 | N.D. |
| Sr | | 293 | 126 | 96 |
| Y | | 27 | 32 | 21 |
| Zr | | 62 | 106 | 55 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | 3 | 3 | 2 |
| Nb | | 2.4 | 4.9 | 2.4 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | | |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 0.276 | 1.785 | 0.074 |
| Ba | | 78 | 124 | 41 |
| Hf | | 2 | 2.9 | 1.6 |
| Ta | | 0.18 | 0.33 | 0.17 |
| W | | N.D. | 3 | N.D. |
| | | continued | continued | continued |
| Pb | 3 | 15 | 5 | 5 |
| Th | | 0.54 | 0.67 | 0.34 |
| U | | 0.135 | 0.173 | 0.082 |
| La | | 5.17 | 7.21 | 3.65 |
| Ce | | 12.74 | 18.63 | 9.36 |
| Pr | | 1.795 | 2.709 | 1.406 |
| Nd | | 8.58 | 12.77 | 6.82 |
| Sm | | 2.62 | 3.78 | 2.09 |
| Eu | | 0.728 | 1.369 | 0.688 |
| Gd | | 3.657 | 4.904 | 2.869 |
| Tb | | 0.649 | 0.846 | 0.517 |
| Dy | | 4.446 | 5.546 | 3.526 |
| Ho | | 0.959 | 1.212 | 0.795 |
| Er | | 2.906 | 3.654 | 2.413 |
| Tm | | 0.428 | 0.55 | 0.363 |
| Yb | | 2.75 | 3.58 | 2.41 |
| Lu | | 0.424 | 0.564 | 0.37 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | 20.75 |
| Pt | 1 | 1.21 | N.D. | 17.4 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | **03-BRB-177** | **03-BRB-190** | **03-BRB-405** |
|---|---|---|---|
| **Easting (Zone 17)** | 557593 | 549266 | 570908 |
| **Northing** | 5324809 | 5318534 | 5327446 |
| **Datum** | NAD 83 | NAD 83 | NAD 83 |
| **Township** | Eby | Burt | Otto |
| **Rock Type** | mafic flow | amphibolitic basalt | mafic amphibolite |

|  | **Det. Limit** |  |  |  |
|---|---|---|---|---|
| SiO2 (wt.%) |  | 48.75 | 55.27 | 54.09 |
| TiO2 |  | 1.00 | 1.49 | 1.18 |
| Al2O3 |  | 13.89 | 11.28 | 15.70 |
| Fe2O3 |  | 13.78 | 15.44 | 8.97 |
| MnO |  | 0.19 | 0.20 | 0.18 |
| MgO |  | 7.03 | 4.71 | 5.57 |
| CaO |  | 10.21 | 8.95 | 8.77 |
| Na2O3 |  | 1.36 | 1.06 | 2.26 |
| K2O |  | 0.19 | 0.13 | 1.12 |
| P2O5 |  | 0.08 | 0.14 | 0.11 |
| LOI |  | 2.78 | 0.79 | 1.50 |
| **total** |  | **99.26** | **99.46** | **99.45** |
| CO2 | 0.03 | 0.19 | 0.14 | 0.15 |
| S | 0.01 | 0.04 | 0.02 | 0.31 |
| Ti (ppm) |  | 5994 | 8931.06 | 7072.92 |
| Li |  | 19 | 9 | 22 |
| Be | 0.01 | 0.28 | 0.39 | 0.35 |
| Sc |  | 31.7 | 26.2 | 39.9 |
| V |  | 264.3 | 283.3 | 308 |
| Cr |  | 279 | 101 | 245 |
| Co | 1 | 41 | 29 | 60 |
| Ni | 3 | 86 | 37 | 108 |
| Cu | 3 | 103 | 53 | 96 |
| Zn |  | 105 | 100 | 129 |
| Ga |  | 20 | 20 | 19 |
| Rb |  | 3 | 2 | 36.9 |
| Sr |  | 135 | 128 | 115.7 |
| Y |  | 24 | 36 | 27.22 |
| Zr |  | 66 | 109 | 95.6 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag |  | 2 | 3 | 2 |
| Nb |  | 2.9 | 4.3 | 3.7 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd |  |  |  | N.D. |
| Sn |  | N.D. | N.D. |  |
| Cs |  | 0.126 | 0.042 | 1.199 |
| Ba |  | 68 | 37 | 321 |
| Hf |  | 2 | 3.1 | 2.7 |
| Ta |  | 0.2 | 0.29 | 0.27 |
| W |  | N.D. | 2 | 3 |

|  |  | **03-BRB-177** | **03-BRB-190** | **03-BRB-405** |
|---|---|---|---|---|
|  |  | continued | continued | continued |
|  | **Det. Limit** |  |  |  |
| Pb | 3 | N.D. | 6 | 6 |
| Th |  | 0.33 | 0.62 | 0.52 |
| U |  | 0.084 | 0.163 | 0.149 |
| La |  | 3.83 | 6.75 | 4.84 |
| Ce |  | 10.14 | 17.71 | 12.72 |
| Pr |  | 1.605 | 2.71 | 1.947 |
| Nd |  | 8.11 | 13.16 | 9.92 |
| Sm |  | 2.58 | 4.02 | 3.13 |
| Eu |  | 0.913 | 1.319 | 1.297 |
| Gd |  | 3.55 | 5.271 | 4.132 |
| Tb |  | 0.632 | 0.905 | 0.738 |
| Dy |  | 4.198 | 6.015 | 4.866 |
| Ho |  | 0.935 | 1.325 | 1.07 |
| Er |  | 2.831 | 4.01 | 3.204 |
| Tm |  | 0.42 | 0.604 | 0.455 |
| Yb |  | 2.78 | 3.94 | 3 |
| Lu |  | 0.426 | 0.604 | 0.45 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | 2.25 | N.D. | N.D. |
| Pt | 1 | 6.18 | 1.86 | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **03-BRB-434** | **03-BRB-493** | **03-BRB-495** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 572923 | 566936 | 557036 |
| **Northing** | | 5326084 | 5322037 | 5322365 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Eby | Eby |
| **Rock Type** | | recrystallized flow/gabbro | massive mafic flow | mafic amphibolite |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 49.87 | 46.50 | 50.23 |
| TiO2 | | 0.55 | 1.70 | 1.20 |
| Al2O3 | | 15.37 | 14.26 | 14.06 |
| Fe2O3 | | 10.12 | 18.79 | 15.47 |
| MnO | | 0.18 | 0.32 | 0.23 |
| MgO | | 7.73 | 3.94 | 5.66 |
| CaO | | 10.95 | 10.30 | 9.36 |
| Na2O3 | | 2.54 | 2.21 | 2.07 |
| K2O | | 0.51 | 0.32 | 0.27 |
| P2O5 | | 0.05 | 0.17 | 0.11 |
| LOI | | 1.57 | 0.84 | 1.21 |
| **total** | | **99.44** | **99.35** | **99.87** |
| CO2 | 0.03 | 0.17 | 0.12 | 0.17 |
| S | 0.01 | 0.02 | 0.01 | 0.07 |
| Ti (ppm) | | 3296.7 | 10189.8 | 7192.8 |
| Li | | 16 | 12 | 15 |
| Be | 0.01 | 0.19 | 0.38 | 0.33 |
| Sc | | 26.2 | 27.3 | 40.4 |
| V | | 170.9 | 300.7 | >320.0 |
| Cr | | 338 | 58 | 65 |
| Co | 1 | 31 | 39 | 50 |
| Ni | 3 | 65 | 41 | 28 |
| Cu | 3 | 10 | 7 | 114 |
| Zn | | 56 | 144 | 123 |
| Ga | | 15 | 22 | 20 |
| Rb | | 18 | 5 | 9.54 |
| Sr | | 229 | 114 | 100.2 |
| Y | | 15 | 40 | 29.96 |
| Zr | | 36 | 118 | 86.9 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | 2 | 3 | 3 |
| Nb | | 1.8 | 4.7 | 3.6 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | | N.D. |
| Sn | | N.D. | N.D. | |
| Cs | | 0.376 | 0.129 | 0.28 |
| Ba | | 145 | 111 | 44 |
| Hf | | 1.1 | 3.3 | 2.5 |
| Ta | | N.D. | 0.37 | 0.26 |
| W | | N.D. | N.D. | 3 |
| | | **03-BRB-434** continued | **03-BRB-493** continued | **03-BRB-495** continued |
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | N.D. | N.D. |
| Th | | 0.22 | 0.62 | 0.46 |
| U | | 0.056 | 0.162 | 0.112 |
| La | | 2.52 | 5.85 | 5.01 |
| Ce | | 6.82 | 16.11 | 13.31 |
| Pr | | 1.023 | 2.486 | 2.033 |
| Nd | | 4.98 | 12.66 | 9.96 |
| Sm | | 1.58 | 4.11 | 3.19 |
| Eu | | 0.612 | 1.353 | 1.09 |
| Gd | | 2.176 | 5.733 | 4.377 |
| Tb | | 0.389 | 1.005 | 0.783 |
| Dy | | 2.614 | 6.679 | 5.262 |
| Ho | | 0.578 | 1.493 | 1.149 |
| Er | | 1.748 | 4.478 | 3.52 |
| Tm | | 0.26 | 0.678 | 0.529 |
| Yb | | 1.71 | 4.46 | 3.44 |
| Lu | | 0.264 | 0.68 | 0.533 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | 7.65 | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 3.** Geochemistry of mafic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **03-BRB-500** | **03-BRB-616** | **03-BRB-645** | **03-BRB-673** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 559842 | 555080 | 543174 | 560817 |
| **Northing** | | 5324716 | 5324808 | 5316382 | 5324143 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | |
| **Township** | | Eby | Eby | Flavelle | Eby |
| **Rock Type** | | massive mafic flow | massive mafic flow | pillowed flow | mg, recrystallized basalt |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 51.32 | 49.63 | 60.77 | 46.24 |
| TiO2 | | 1.54 | 1.14 | 1.51 | 1.95 |
| Al2O3 | | 12.12 | 13.90 | 12.84 | 12.62 |
| Fe2O3 | | 15.72 | 14.18 | 11.46 | 19.52 |
| MnO | | 0.19 | 0.21 | 0.21 | 0.26 |
| MgO | | 3.73 | 6.58 | 2.49 | 5.51 |
| CaO | | 13.61 | 7.29 | 3.45 | 9.47 |
| Na2O3 | | < 0.01 | 3.26 | 3.95 | 2.71 |
| K2O | | 0.09 | 0.35 | 0.13 | 0.31 |
| P2O5 | | 0.15 | 0.10 | 0.14 | 0.08 |
| LOI | | 1.48 | 2.72 | 2.29 | 0.88 |
| **total** | | **99.95** | **99.36** | **99.24** | **99.55** |
| CO2 | 0.03 | 0.18 | 0.36 | 0.64 | 0.13 |
| S | 0.01 | 0.04 | 0.01 | N.D. | 0.06 |
| Ti (ppm) | | 9230.76 | 6833.16 | 9050.94 | 11688.3 |
| Li | | 8 | 15 | 15 | 10 |
| Be | 0.01 | 0.42 | 0.35 | 0.28 | 0.43 |
| Sc | | 31.6 | 31.7 | 26.5 | 36.4 |
| V | | 306.1 | 276.4 | 244.3 | >320.0 |
| Cr | | 46 | 160 | 66 | 60 |
| Co | 1 | 41 | 39 | 32 | 41 |
| Ni | 3 | 23 | 66 | 41 | 34 |
| Cu | 3 | 40 | 98 | 21 | 33 |
| Zn | | 119 | 125 | 114 | 130 |
| Ga | | 22 | 19 | 15 | 23 |
| Rb | | 3.43 | 8 | 8 | 5 |
| Sr | | 124 | 118 | 45 | 104 |
| Y | | 36.18 | 28 | 31 | 28 |
| Zr | | 110.4 | 78 | 104 | 77 |
| As | 1 | N.D. | N.D. | N.D. | N.D. |
| Ag | | 3 | 2 | 2 | 3 |
| Nb | | 4.4 | 3.6 | 3.9 | 3.5 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | | | |
| Sn | | | N.D. | N.D. | N.D. |
| Cs | | 0.186 | 0.398 | 0.206 | 0.383 |
| Ba | | N.D. | 87 | 92 | 74 |
| Hf | | 3 | 2.3 | 2.7 | 2.2 |
| Ta | | 0.33 | 0.28 | 0.31 | 0.29 |
| W | | N.D. | N.D. | N.D. | N.D. |

| | | **03-BRB-500** continued | **03-BRB-616** continued | **03-BRB-645** continued | **03-BRB-673** continued |
|---|---|---|---|---|---|
| | **Det. Limit** | | | | |
| Pb | 3 | 8 | 5 | N.D. | N.D. |
| Th | | 0.6 | 0.4 | 0.48 | 0.29 |
| U | | 0.162 | 0.103 | 0.119 | 0.045 |
| La | | 6.88 | 4.87 | 5.07 | 3.42 |
| Ce | | 17.36 | 12.64 | 13.34 | 9.16 |
| Pr | | 2.621 | 1.98 | 2.028 | 1.494 |
| Nd | | 13.15 | 10.08 | 10.04 | 8.03 |
| Sm | | 3.95 | 3.12 | 3.2 | 2.72 |
| Eu | | 1.292 | 1.068 | 0.825 | 1.032 |
| Gd | | 5.205 | 4.225 | 4.361 | 3.859 |
| Tb | | 0.933 | 0.749 | 0.778 | 0.681 |
| Dy | | 6.228 | 5.011 | 5.143 | 4.694 |
| Ho | | 1.358 | 1.101 | 1.176 | 1.046 |
| Er | | 4.122 | 3.377 | 3.52 | 3.108 |
| Tm | | 0.615 | 0.506 | 0.538 | 0.467 |
| Yb | | 4.04 | 3.36 | 3.6 | 3.16 |
| Lu | | 0.63 | 0.509 | 0.548 | 0.496 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | 1.42 | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 4.** Geochemistry of intermediate and felsic metavolcanic rocks - Highway 66 area.

| **Sample** | Det. Limit | **02-BRB-056** | **02-BRB-077** | **02-BRB-101** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 526425 | 528511 | 550909 |
| **Northing** | | 5312894 | 5309878 | 5319575 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Cairo | Burt |
| **Rock Type** | | bedded intermediate tuff | intermediate tuff/flow | mafic/intermed. flow |
| SiO2 (wt.%) | | 57.65 | 62.83 | 58.88 |
| TiO2 | | 1.06 | 0.79 | 0.82 |
| Al2O3 | | 13.69 | 16.45 | 16.37 |
| Fe2O3 | | 9.06 | 5.66 | 8.02 |
| MnO | | 0.18 | 0.07 | 0.11 |
| MgO | | 4.77 | 1.74 | 3.66 |
| CaO | | 5.52 | 3.41 | 5.94 |
| Na2O3 | | 3.93 | 4.21 | 5.18 |
| K2O | | 0.57 | 1.56 | 0.22 |
| P2O5 | | 0.06 | 0.19 | 0.12 |
| LOI | | 2.81 | 2.08 | 0.56 |
| **total** | | **99.32** | **98.98** | **99.88** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 6353.64 | 4735.26 | 4915.08 |
| Li | | 40 | 20 | 10 |
| Be | 0.01 | 0.36 | 0.49 | 0.45 |
| Sc | | 45.6 | 12.1 | 18.96 |
| V | | 305.63 | 133.05 | 141.58 |
| Cr | | 265 | 146 | 54 |
| Co | 1 | 68.62 | 29.14 | 36.52 |
| Ni | 3 | 113 | 49 | 62 |
| Cu | 3 | 70 | 28 | 9 |
| Zn | | 417 | 59 | 82 |
| Ga | | 19 | 19 | 19 |
| Rb | | 20.65 | 51.35 | 3.95 |
| Sr | | 200.00 | 285.50 | 324.30 |
| Y | | 18.72 | 13.85 | 14.67 |
| Zr | | 65.50 | 152.60 | 124.00 |
| As | 1 | 106.00 | N.D. | N.D. |
| Ag | | 2.00 | 2.00 | 2.00 |
| Nb | | 2.80 | 7.30 | 4.70 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 0.73 | 1.26 | 0.17 |
| Ba | | 227.00 | 241.00 | 90.00 |
| Hf | | 2.00 | 3.70 | 3.10 |
| Ta | | 0.34 | 0.62 | 0.52 |
| W | | 16.00 | 20.00 | 20.00 |

| | Det. Limit | **02-BRB-056**<br>continued | **02-BRB-077**<br>continued | **02-BRB-101**<br>continued |
|---|---|---|---|---|
| Pb | 3 | 1074.00 | N.D. | N.D. |
| Th | | 0.49 | 2.20 | 1.40 |
| U | | 0.17 | 0.54 | 0.37 |
| La | | 4.77 | 19.11 | 13.10 |
| Ce | | 11.77 | 42.97 | 29.64 |
| Pr | | 1.79 | 5.72 | 3.86 |
| Nd | | 8.36 | 22.26 | 15.07 |
| Sm | | 2.42 | 3.95 | 3.20 |
| Eu | | 0.96 | 1.29 | 1.10 |
| Gd | | 3.07 | 3.37 | 3.13 |
| Tb | | 0.58 | 0.48 | 0.49 |
| Dy | | 3.57 | 2.57 | 2.81 |
| Ho | | 0.84 | 0.51 | 0.61 |
| Er | | 2.46 | 1.36 | 1.79 |
| Tm | | 0.38 | 0.18 | 0.27 |
| Yb | | 2.13 | 1.28 | 1.53 |
| Lu | | 0.37 | 0.20 | 0.26 |
| Au (ppb) | 6 | N.M. | N.M. | N.M. |
| Pd | 2 | N.M. | N.M. | N.M. |
| Pt | 1 | N.M. | N.M. | N.M. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 4.** Geochemistry of intermediate and felsic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **02-BRB-103** | **02-BRB-113** | **02-BRB-122** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 550646 | 545213 | 544704 |
| **Northing** | | 5319157 | 5327277 | 5326725 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Burt | Burt | Burt |
| **Rock Type** | | intermediate tuff | intermediate tuff/flow | calc-silicate altered flow |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 56.77 | 58.2 | 58.52 |
| TiO2 | | 1.02 | 0.58 | 0.61 |
| Al2O3 | | 17.2 | 14.46 | 14.31 |
| Fe2O3 | | 8.37 | 6.55 | 7.03 |
| MnO | | 0.11 | 0.1 | 0.13 |
| MgO | | 4.1 | 7.66 | 6.02 |
| CaO | | 5.31 | 5.35 | 7.85 |
| Na2O3 | | 4.28 | 2.6 | 0.64 |
| K2O | | 1.51 | 2.39 | 2.35 |
| P2O5 | | 0.17 | 0.09 | 0.09 |
| LOI | | 1.09 | 2.21 | 2.26 |
| **total** | | **99.93** | **100.2** | **99.81** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 6113.88 | 3476.52 | 3656.34 |
| Li | | 32 | 42 | 30 |
| Be | 0.01 | 0.57 | 0.48 | 0.68 |
| Sc | | 21.76 | 17.59 | 18.31 |
| V | | 160.36 | 107.6 | 116.24 |
| Cr | | 87 | 394 | 430 |
| Co | 1 | 40.06 | 42.66 | 43.16 |
| Ni | 3 | 81 | 202 | 232 |
| Cu | 3 | 21 | 4 | 16 |
| Zn | | 119 | 73 | 85 |
| Ga | | 20 | 16 | 16 |
| Rb | | 30.66 | 103.42 | 78.04 |
| Sr | | 265.00 | 236.00 | 131.10 |
| Y | | 18.03 | 14.03 | 13.40 |
| Zr | | 146.70 | 115.20 | 113.50 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | 2.00 | 1.00 | 2.00 |
| Nb | | 5.60 | 4.10 | 4.30 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 1.12 | 4.73 | 2.95 |
| Ba | | 425.00 | 356.00 | 289.00 |
| Hf | | 3.90 | 3.10 | 2.90 |
| Ta | | 0.55 | 0.46 | 0.47 |
| W | | 19.00 | 17.00 | 19.00 |

| | | **02-BRB-103** | **02-BRB-113** | **02-BRB-122** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | N.D. | N.D. |
| Th | | 1.63 | 1.45 | 1.36 |
| U | | 0.42 | 0.48 | 0.44 |
| La | | 10.77 | 6.10 | 8.44 |
| Ce | | 26.19 | 16.26 | 18.91 |
| Pr | | 3.47 | 1.91 | 2.56 |
| Nd | | 14.02 | 7.89 | 10.77 |
| Sm | | 3.23 | 2.30 | 2.45 |
| Eu | | 1.13 | 0.78 | 0.87 |
| Gd | | 3.38 | 2.58 | 2.61 |
| Tb | | 0.58 | 0.43 | 0.44 |
| Dy | | 3.35 | 2.54 | 2.56 |
| Ho | | 0.72 | 0.55 | 0.53 |
| Er | | 2.10 | 1.51 | 1.59 |
| Tm | | 0.32 | 0.24 | 0.25 |
| Yb | | 1.81 | 1.47 | 1.48 |
| Lu | | 0.33 | 0.24 | 0.26 |
| Au (ppb) | 6 | N.M. | N.M. | N.M. |
| Pd | 2 | N.M. | N.M. | N.M. |
| Pt | 1 | N.M. | N.M. | N.M. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 4.** Geochemistry of intermediate and felsic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | Det. Limit | **02-BRB-225** | **JAA-00-252** | **JAA-00-253** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 531791 | 530405 | 527701 |
| **Northing** | | 5311167 | 5311040 | 5323146 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Cairo | IR.72 |
| **Rock Type** | | intermediate flow | mafic volcanic (intermediate volcanic) | intermediate amygdaloidal flow |
| SiO2 (wt.%) | | 59.38 | 61.28 | 58.4 |
| TiO2 | | 0.87 | 1.18 | 0.69 |
| Al2O3 | | 16.22 | 15.28 | 16.02 |
| Fe2O3 | | 9.46 | 5.66 | 8.14 |
| MnO | | 0.4 | 0.06 | 0.13 |
| MgO | | 1.92 | 4.36 | 4.61 |
| CaO | | 4.68 | 3.19 | 6.89 |
| Na2O3 | | 1.66 | 4.75 | 2.99 |
| K2O | | 2.13 | 1.65 | 0.46 |
| P2O5 | | 0.14 | 0.21 | 0.12 |
| LOI | | 2.54 | 2.24 | 1.55 |
| **total** | | **99.39** | **99.86** | **100** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 5214.78 | 7072.92 | 4135.86 |
| Li | | 22 | 15.6 | 13.77 |
| Be | 0.01 | 0.83 | N.D. | N.D. |
| Sc | | 12.65 | 17 | 17 |
| V | | 152.27 | 134 | 116 |
| Cr | | 49 | 118.42 | 169.04 |
| Co | 1 | 32.6 | 15.17 | 26.83 |
| Ni | 3 | 79 | 70.77 | 105.19 |
| Cu | 3 | 41 | 35.49 | 47.52 |
| Zn | | 96 | 42.25 | 61.63 |
| Ga | | 19 | 17.45 | 14.24 |
| Rb | | 63.62 | 36.46 | 17.27 |
| Sr | | 223.20 | 142 | 171 |
| Y | | 13.60 | 14.68 | 14.61 |
| Zr | | 117.50 | 138.91 | 108.88 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | 2.00 | N.M. | N.M. |
| Nb | | 4.90 | 8.52 | 4.89 |
| Mo | <1 | N.D. | 7.45 | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | 0.68 | 0.85 |
| Cs | | 1.10 | 0.49 | 1.14 |
| Ba | | 652.00 | 281.89 | 73.31 |
| Hf | | 3.00 | 4.2 | 3.53 |
| Ta | | 0.52 | 0.63 | 0.46 |
| W | | 25.00 | 0.53 | 0.24 |

| | Det. Limit | **02-BRB-225**<br>continued | **JAA-00-252**<br>continued | **JAA-00-253**<br>continued |
|---|---|---|---|---|
| Pb | 3 | 7.00 | 7.29 | 3.38 |
| Th | | 1.60 | 1.82 | 2.14 |
| U | | 0.47 | 0.88 | 0.58 |
| La | | 13.95 | 15.81 | 13.52 |
| Ce | | 30.02 | 36.25 | 28.65 |
| Pr | | 3.88 | 4.67 | 3.53 |
| Nd | | 15.02 | 19.12 | 13.44 |
| Sm | | 3.15 | 3.85 | 2.87 |
| Eu | | 1.09 | 1.05 | 0.81 |
| Gd | | 3.04 | 3.1 | 2.83 |
| Tb | | 0.49 | 0.45 | 0.42 |
| Dy | | 2.55 | 2.86 | 2.68 |
| Ho | | 0.54 | 0.57 | 0.56 |
| Er | | 1.54 | 1.57 | 1.52 |
| Tm | | 0.24 | 0.24 | 0.23 |
| Yb | | 1.49 | 1.53 | 1.55 |
| Lu | | 0.23 | 0.26 | 0.26 |
| Au (ppb) | 6 | N.M. | N.D. | N.D. |
| Pd | 2 | N.M. | N.D. | N.D. |
| Pt | 1 | N.M. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 4.** Geochemistry of intermediate and felsic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | Det. Limit | **03-BRB-195** | **03-BRB-642** | **03-BRB-651** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 550139 | 543431 | 543407 |
| **Northing** | | 5320488 | 5316115 | 5316929 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Burt | Flavelle | Flavelle |
| **Rock Type** | | amphibolitic intermediate flow | intermediate volcanic tuff | intermediate volcanic tuff |
| SiO2 (wt.%) | | 53.81 | 61.29 | 61.31 |
| TiO2 | | 1.38 | 0.49 | 0.91 |
| Al2O3 | | 14.38 | 14.75 | 15.00 |
| Fe2O3 | | 13.30 | 6.33 | 7.88 |
| MnO | | 0.20 | 0.09 | 0.10 |
| MgO | | 4.69 | 5.57 | 2.48 |
| CaO | | 7.25 | 3.68 | 6.54 |
| Na2O3 | | 1.54 | 1.86 | 1.89 |
| K2O | | 0.83 | 2.07 | 0.65 |
| P2O5 | | 0.21 | 0.09 | 0.22 |
| LOI | | 1.42 | 3.50 | 2.65 |
| **total** | | **99.01** | **99.72** | **99.63** |
| CO2 | 0.03 | 0.15 | 0.51 | 0.36 |
| S | 0.01 | 0.14 | N.D. | N.D. |
| Ti (ppm) | | 8271.72 | 2937.06 | 5454.54 |
| Li | | 22 | 58 | 15 |
| Be | 0.01 | 0.45 | 0.43 | 0.41 |
| Sc | | 21 | 11.7 | 12.1 |
| V | | 268.4 | 79.7 | 107.9 |
| Cr | | 38 | 367 | 23 |
| Co | 1 | 31 | 23 | 9 |
| Ni | 3 | 30 | 127 | 23 |
| Cu | 3 | 48 | 10 | N.D. |
| Zn | | 115 | 73 | 69 |
| Ga | | 20 | 15 | 17 |
| Rb | | 31 | 75.74 | 22.21 |
| Sr | | 151 | 302.6 | 205.5 |
| Y | | 27 | 10.88 | 18.56 |
| Zr | | 134 | 122.2 | 164.7 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | 2 | N.D. | N.D. |
| Nb | | 6.4 | 4.4 | 5.9 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 0.592 | 3.941 | 0.37 |
| Ba | | 145 | 450 | 243 |
| Hf | | 3.5 | 3.2 | 4.1 |
| Ta | | 0.45 | 0.48 | 0.48 |
| W | | N.D. | N.D. | N.D. |

| | Det. Limit | **03-BRB-195** continued | **03-BRB-642** continued | **03-BRB-651** continued |
|---|---|---|---|---|
| Pb | 3 | 6 | 8 | N.D. |
| Th | | 1.25 | 4.3 | 2.02 |
| U | | 0.329 | 0.861 | 0.499 |
| La | | 12.24 | 13.01 | 17.46 |
| Ce | | 29.05 | 25.59 | 39.32 |
| Pr | | 3.941 | 2.977 | 4.979 |
| Nd | | 17.02 | 11.34 | 20.63 |
| Sm | | 4.08 | 2.33 | 4.24 |
| Eu | | 1.329 | 0.668 | 1.219 |
| Gd | | 4.549 | 2.211 | 3.921 |
| Tb | | 0.715 | 0.327 | 0.573 |
| Dy | | 4.496 | 1.936 | 3.399 |
| Ho | | 0.957 | 0.41 | 0.706 |
| Er | | 2.856 | 1.187 | 1.996 |
| Tm | | 0.429 | 0.174 | 0.292 |
| Yb | | 2.8 | 1.18 | 1.9 |
| Lu | | 0.43 | 0.185 | 0.289 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | 1.15 | 1.7 | 1.3 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 4.** Geochemistry of intermediate and felsic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | **Det. Limit** | **03-BRB-661** | **03-BRB-342** | **03-BRB-186** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 545242 | 556545 | 560814 |
| **Northing** | | 5326033 | 5323010 | 5321844 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Burt | Eby | Eby |
| **Rock Type** | | amphibolitic intermediate metavolcanic flow | pillowed flow | felsic tuff/flow |
| $SiO_2$ (wt.%) | | 57.56 | 55.27 | 67.73 |
| $TiO_2$ | | 0.78 | 1.22 | 0.31 |
| $Al_2O_3$ | | 18.11 | 14.62 | 17.63 |
| $Fe_2O_3$ | | 7.64 | 12.60 | 3.18 |
| MnO | | 0.10 | 0.17 | 0.12 |
| MgO | | 3.29 | 3.98 | 0.51 |
| CaO | | 6.64 | 6.75 | 2.96 |
| $Na_2O_3$ | | 3.93 | 3.10 | 3.56 |
| $K_2O$ | | 1.08 | 0.28 | 2.24 |
| $P_2O_5$ | | 0.13 | 0.20 | 0.12 |
| LOI | | 1.16 | 1.27 | 1.80 |
| **total** | | **100.42** | **99.46** | **100.16** |
| $CO_2$ | 0.03 | 0.17 | 0.15 | 0.19 |
| S | 0.01 | 0.01 | 0.01 | 0.16 |
| Ti (ppm) | | 4675.32 | 7312.68 | 1858.14 |
| Li | | 23 | 15 | 22 |
| Be | 0.01 | 0.44 | 0.44 | 0.3 |
| Sc | | 15.8 | 22.4 | 2.1 |
| V | | 120.2 | 246.1 | 16.4 |
| Cr | | 63 | 29 | 14 |
| Co | 1 | 21 | 29 | 4 |
| Ni | 3 | 54 | 26 | 4 |
| Cu | 3 | 24 | 26 | 4 |
| Zn | | 63 | 111 | 31 |
| Ga | | 18 | 19 | 18 |
| Rb | | 40.43 | 8 | 51.16 |
| Sr | | 323.8 | 205 | 328 |
| Y | | 17.48 | 25 | 5.49 |
| Zr | | 136.1 | 134 | 130 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | N.D. | 2 | N.D. |
| Nb | | 4.9 | 6.4 | 2.8 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 1.501 | 0.302 | 1.03 |
| Ba | | 312 | 110 | 487 |
| Hf | | 3.5 | 3.6 | 3.2 |
| Ta | | 0.39 | 0.47 | 0.25 |
| W | | N.D. | N.D. | N.D. |

| | **Det. Limit** | **03-BRB-661**<br>continued | **03-BRB-342**<br>continued | **03-BRB-186**<br>continued |
|---|---|---|---|---|
| Pb | 3 | 11 | N.D. | 7 |
| Th | | 1.62 | 1.72 | 1.66 |
| U | | 0.454 | 0.409 | 0.51 |
| La | | 12.1 | 12.17 | 6.83 |
| Ce | | 26.74 | 29.14 | 16.82 |
| Pr | | 3.452 | 3.798 | 1.869 |
| Nd | | 14.74 | 16.2 | 7.18 |
| Sm | | 3.32 | 3.88 | 1.36 |
| Eu | | 0.993 | 1.227 | 0.523 |
| Gd | | 3.287 | 4.268 | 1.132 |
| Tb | | 0.516 | 0.701 | 0.165 |
| Dy | | 3.071 | 4.465 | 0.94 |
| Ho | | 0.649 | 0.966 | 0.193 |
| Er | | 1.867 | 2.832 | 0.562 |
| Tm | | 0.275 | 0.422 | 0.086 |
| Yb | | 1.8 | 2.76 | 0.57 |
| Lu | | 0.283 | 0.425 | 0.09 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | 1.7 | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 4.** Geochemistry of intermediate and felsic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **03-BRB-337** | **03-BRB-427** | **03-BRB-509** | **02-BRB-228** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 562257 | 572385 | 561941 | 526043 |
| **Northing** | | 5322279 | 5326090 | 5324596 | 5315391 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Eby | Otto | Eby | Cairo |
| **Rock Type** | | qtz-feldspar porphyry | felsic tuff/flow | felsic rock/tuff-flow? | feldspar-quartz porphyry |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 66.87 | 71.78 | 70.77 | 65.35 |
| TiO2 | | 0.33 | 0.36 | 0.19 | 0.36 |
| Al2O3 | | 16.14 | 10.78 | 16.09 | 14.4 |
| Fe2O3 | | 3.16 | 1.73 | 1.58 | 5.24 |
| MnO | | 0.04 | 0.06 | 0.02 | 0.1 |
| MgO | | 1.26 | 0.55 | 0.93 | 2.44 |
| CaO | | 3.06 | 5.71 | 1.33 | 2.47 |
| Na2O3 | | 4.82 | 2.65 | 6.66 | 3.56 |
| K2O | | 2.50 | 2.55 | 1.61 | 2 |
| P2O5 | | 0.13 | 0.12 | 0.08 | 0.07 |
| LOI | | 1.65 | 3.32 | 1.01 | 3.73 |
| **total** | | **99.96** | **99.61** | **100.27** | **99.72** |
| CO2 | 0.03 | 0.52 | 2.64 | 0.31 | N.M. |
| S | 0.01 | 0.28 | 0.04 | N.D. | N.M. |
| Ti (ppm) | | 1978.02 | 2157.84 | 1138.86 | 2157.84 |
| Li | | 18 | 6 | 7 | 34 |
| Be | 0.01 | 0.89 | 0.26 | 0.75 | 0.45 |
| Sc | | 4.4 | 4.8 | 1.6 | 4.88 |
| V | | 40.5 | 46.8 | 20.2 | 39.02 |
| Cr | | 27 | 66 | 43 | 8 |
| Co | 1 | 9 | 10 | 4 | 13.67 |
| Ni | 3 | 19 | 15 | 13 | 27 |
| Cu | 3 | N.D. | 21 | N.D. | N.D. |
| Zn | | 49 | 18 | 30 | 113 |
| Ga | | 19 | 11 | 22 | 17 |
| Rb | | 51.85 | 40.15 | 19.77 | 49.62 |
| Sr | | 668.3 | 179.2 | 902.5 | 115.90 |
| Y | | 6.86 | 5.37 | 3.71 | 5.79 |
| Zr | | 110.8 | 70.6 | 91.9 | 109.60 |
| As | 1 | N.D. | N.D. | N.D. | N.D. |
| Ag | | N.D. | N.D. | N.D. | 1.00 |
| Nb | | 4.2 | 2.7 | 1.8 | 2.50 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. | N.D. |
| Cs | | 1.383 | 0.256 | 0.19 | N.D. |
| Ba | | 1227 | 338 | 620 | 7.48 |
| Hf | | 2.9 | 1.7 | 2.5 | 2.80 |
| Ta | | 0.31 | 0.24 | 0.18 | 0.36 |
| W | | N.D. | N.D. | N.D. | 19.00 |

| | **Det. Limit** | **03-BRB-337** continued | **03-BRB-427** continued | **03-BRB-509** continued | **02-BRB-228** continued |
|---|---|---|---|---|---|
| Pb | 3 | 12 | N.D. | 9 | N.D. |
| Th | | 1.42 | 1.08 | 2.11 | N.D. |
| U | | 0.608 | 0.298 | 0.649 | 0.28 |
| La | | 13.13 | 9.3 | 14.54 | 8.96 |
| Ce | | 27.78 | 20.26 | 31.68 | 17.46 |
| Pr | | 3.537 | 2.462 | 4.001 | 2.07 |
| Nd | | 14.51 | 9.68 | 16.3 | 7.52 |
| Sm | | 2.89 | 1.78 | 3.23 | 1.48 |
| Eu | | 0.695 | 0.521 | 0.855 | 0.44 |
| Gd | | 2.176 | 1.36 | 2.01 | 1.21 |
| Tb | | 0.273 | 0.187 | 0.203 | 0.17 |
| Dy | | 1.371 | 1.025 | 0.833 | 1.07 |
| Ho | | 0.248 | 0.2 | 0.129 | 0.20 |
| Er | | 0.688 | 0.566 | 0.298 | 0.58 |
| Tm | | 0.093 | 0.078 | 0.04 | 0.09 |
| Yb | | 0.61 | 0.52 | 0.26 | 0.51 |
| Lu | | 0.09 | 0.077 | 0.038 | 0.10 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 4.** Geochemistry of intermediate and felsic metavolcanic rocks - Highway 66 area (cont'd).

| **Sample** | | **02-BRB-249** | **02JAA-0018** | **02-BRB-059** | **02-BRB-064** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 528002 | 528240 | 526494 | 526503 |
| **Northing** | | 5310042 | 5310310 | 5312138 | 5311390 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Cairo | Cairo Tp - Montreal River | Cairo Tp - Montreal River |
| **Rock Type** | | felsic flow | brecciated felsic flow | massive sandstone | arkosic sandstone |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 73.87 | 73.11 | 66.74 | 68.24 |
| TiO2 | | 0.64 | 0.66 | 0.55 | 0.49 |
| Al2O3 | | 13.35 | 13.07 | 14.05 | 14.17 |
| Fe2O3 | | 1.52 | 4.28 | 4.5 | 3.71 |
| MnO | | 0.01 | 0.03 | 0.07 | 0.08 |
| MgO | | 0.61 | 1.64 | 3.05 | 1.89 |
| CaO | | 0.65 | 0.46 | 1.04 | 1.03 |
| Na2O3 | | 7.39 | 3.74 | 5.72 | 4.48 |
| K2O | | 0.13 | 1.85 | 1.08 | 3.56 |
| P2O5 | | 0.11 | 0.12 | 0.13 | 0.12 |
| LOI | | 0.74 | 1.92 | 2.1 | 1.46 |
| **total** | | **99.03** | **100.88** | **99.04** | **99.25** |
| CO2 | 0.03 | N.M. | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. | N.M. |
| Ti (ppm) | | 3836.16 | 3956.04 | 3296.7 | 2937.06 |
| Li | | 4 | N.M. | 36 | 20 |
| Be | 0.01 | 0.56 | N.M. | 0.93 | 0.53 |
| Sc | | 8.09 | 11 | 11.01 | 10.17 |
| V | | 14.24 | 15 | 91.96 | 78.14 |
| Cr | | 6 | 9 | 195 | 130 |
| Co | 1 | 9.1 | 14 | 26.88 | 22.51 |
| Ni | 3 | 9 | 10 | 81 | 61 |
| Cu | 3 | N.D. | N.D. | 7 | 19 |
| Zn | | 9 | 23 | 94 | 109 |
| Ga | | 12 | 18 | 18 | 17 |
| Rb | | 1.38 | 78.66 | 33.06 | 101.39 |
| Sr | | 59.00 | 60.06 | 603.70 | 247.00 |
| Y | | 22.77 | 22.68 | 13.14 | 12.29 |
| Zr | | 246.80 | 254.25 | 119.00 | 116.90 |
| As | 1 | N.D. | N.D. | 2.00 | 2.00 |
| Ag | | N.D. | N.D. | 1.00 | 1.00 |
| Nb | | 8.50 | 9.62 | 4.50 | 3.90 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | | |
| Sn | | N.D. | N.D. | N.D. | N.D. |
| Cs | | N.D. | N.D. | 1.17 | 1.26 |
| Ba | | 0.11 | 1.38 | 606.00 | 1763.00 |
| Hf | | 6.10 | 6.38 | 3.10 | 3.00 |
| Ta | | 0.73 | 0.64 | | |
| W | | N.D. | N.D. | 18.00 | 31.00 |

| | **Det. Limit** | **02-BRB-249**<br>continued | **02JAA-0018**<br>continued | **02-BRB-059**<br>continued | **02-BRB-064**<br>continued |
|---|---|---|---|---|---|
| Pb | 3 | N.D. | N.D. | 6.00 | 9.00 |
| Th | | N.D. | N.D. | 4.50 | 4.20 |
| U | | 0.93 | 0.82 | 1.77 | 1.11 |
| La | | 4.60 | 40.11 | 38.80 | 25.57 |
| Ce | | 14.42 | 87.64 | 62.59 | 52.50 |
| Pr | | 2.88 | 10.84 | 7.17 | 6.90 |
| Nd | | 15.16 | 40.16 | 24.70 | 25.34 |
| Sm | | 4.10 | 7.06 | 4.03 | 4.27 |
| Eu | | 1.32 | 1.74 | 1.24 | 1.38 |
| Gd | | 3.90 | 5.42 | 3.23 | 3.37 |
| Tb | | 0.67 | 0.85 | 0.49 | 0.44 |
| Dy | | 3.75 | 4.56 | 2.46 | 2.37 |
| Ho | | 0.84 | 0.86 | 0.49 | 0.49 |
| Er | | 2.34 | 2.36 | 1.44 | 1.33 |
| Tm | | 0.39 | 0.35 | 0.22 | 0.19 |
| Yb | | 2.50 | 2.28 | 1.30 | 1.19 |
| Lu | | 0.38 | 0.37 | 0.19 | 0.20 |
| Au (ppb) | 6 | N.D. | N.D. | N.M. | N.M. |
| Pd | 2 | N.D. | N.D. | N.M. | N.M. |
| Pt | 1 | N.D. | N.D. | N.M. | N.M. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 5.** Geochemistry of alkalic metavolcanic and related intrusive rocks - Highway 66 area.

| **Sample** | **01-BRB-005** | **01-BRB-0016** | **01-BRB-0018** |
|---|---|---|---|
| **Easting (Zone 17)** | 537898 | 538571 | 538245 |
| **Northing** | 5318152 | 5317955 | 5320725 |
| **Datum** | NAD 83 | NAD 83 | NAD 83 |
| **Township** | Holmes | Flavelle | Holmes |
| **Rock Type** | alkalic mafic schist | Alkalic basalt | Trachyte |

|  | **Det. Limit** | **01-BRB-005** | **01-BRB-0016** | **01-BRB-0018** |
|---|---|---|---|---|
| SiO2 (wt.%) |  | 49.63 | 52.25 | 57.87 |
| TiO2 |  | 0.93 | 0.9 | 0.66 |
| Al2O3 |  | 13.04 | 11.72 | 14.4 |
| Fe2O3 |  | 9.84 | 8.68 | 5.61 |
| MnO |  | 0.18 | 0.15 | 0.09 |
| MgO |  | 11.42 | 10.36 | 5.38 |
| CaO |  | 7.38 | 7.86 | 4.88 |
| Na2O3 |  | 2.28 | 1.99 | 4.72 |
| K2O |  | 1.53 | 3.63 | 2.99 |
| P2O5 |  | 0.39 | 0.38 | 0.24 |
| LOI |  | 3.41 | 2.32 | 1.47 |
| **total** |  | **100.03** | **100.24** | **98.31** |
| CO2 | 0.03 | 0.6 | N.M. | N.M. |
| S | 0.01 | N.D. | N.M. | N.M. |
| Ti (ppm) |  | 5574.42 | 5394.6 | 3956.04 |
| Li |  | 41 | 22.24 | 12.03 |
| Be | 0.01 | 1.28 | 2.05 | N.D. |
| Sc |  | 21.1 | 24.2 | 13.23 |
| V |  | 185.4 | 192.5 | 124.8 |
| Cr |  | 721 | 549 | 217 |
| Co | 1 | 47 | 33.9 | 15.9 |
| Ni | 3 | 153 | 110.5 | 102.7 |
| Cu | 3 | N.D. | 14.6 | 9.75 |
| Zn |  | 216 | 138.5 | 62.4 |
| Ga |  | 18 | 16 | 20.5 |
| Rb |  | 64.54 | 64.6 | 70.7 |
| Sr |  | 550.3 | 674.00 | 881.00 |
| Y |  | 21.6 | 19.37 | 15.48 |
| Zr |  | 153.1 | 128.00 | 139.50 |
| As | 1 | 9 | N.D. | N.D. |
| Ag |  | 3 | N.D. | N.D. |
| Nb |  | 5.4 | 3.94 | 4.40 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd |  | N.D. | N.D. | N.D. |
| Sn |  | N.D. | 1.10 | 1.11 |
| Cs |  | 8.55 | 3.46 | 2.40 |
| Ba |  | 576 | 3097.00 | 1678.00 |
| Hf |  | 4.1 | 3.44 | 3.90 |
| Ta |  | 0.36 | N.D. | N.D. |
| W |  | 7 | 0.80 | 0.68 |

|  | **Det. Limit** | **01-BRB-005** continued | **01-BRB-0016** continued | **01-BRB-0018** continued |
|---|---|---|---|---|
| Pb | 3 | 8 | 13.40 | 7.14 |
| Th |  | 5.29 | 4.80 | 7.55 |
| U |  | 1.473 | 1.33 | 1.71 |
| La |  | 30.25 | 26.79 | 42.26 |
| Ce |  | 66.61 | 60.30 | 89.56 |
| Pr |  | 8.6 | 7.87 | 11.10 |
| Nd |  | 36.14 | 33.17 | 43.10 |
| Sm |  | 7.27 | 7.39 | 7.35 |
| Eu |  | 1.922 | 2.52 | 1.99 |
| Gd |  | 6.118 | 6.11 | 5.19 |
| Tb |  | 0.82 | 0.81 | 0.66 |
| Dy |  | 4.358 | 3.90 | 2.88 |
| Ho |  | 0.82 | 0.74 | 0.58 |
| Er |  | 2.223 | 1.75 | 1.35 |
| Tm |  | 0.307 | N.D. | N.D. |
| Yb |  | 1.93 | 1.64 | 1.35 |
| Lu |  | 0.277 | 0.22 | 0.20 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | 1.25 | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

N.M. = not measured

N.D. = not detected

**Table 5.** Geochemistry of alkalic metavolcanic and related intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **01-BRB-0020** | **02-BRB-034** | **02-BRB-039** | **02-BRB-047** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 564062 | 540440 | 536890 | 537774 |
| **Northing** | | 5327921 | 5320340 | 5321273 | 5319044 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Eby | Holmes | Holmes | Holmes |
| **Rock Type** | | Alkalic mafic flow | alkalic breccia | aplitic syenite | alkalic intermed. tuff |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 51.42 | 55.22 | 59.53 | 50.01 |
| TiO2 | | 0.66 | 0.84 | 0.65 | 0.86 |
| Al2O3 | | 13.22 | 12.86 | 14.55 | 11.58 |
| Fe2O3 | | 7.7 | 8.12 | 5.92 | 9.77 |
| MnO | | 0.1 | 0.13 | 0.09 | 0.18 |
| MgO | | 6.75 | 8.02 | 4.78 | 9.34 |
| CaO | | 6.3 | 6.66 | 5.51 | 8.40 |
| Na2O3 | | 4.56 | 4.02 | 4.93 | 0.56 |
| K2O | | 2.41 | 2.6 | 2.26 | 3.98 |
| P2O5 | | 0.29 | 0.3 | 0.22 | 0.72 |
| LOI | | 6.29 | 1.74 | 1.17 | 3.88 |
| total | | **99.7** | **100.51** | **99.62** | **99.28** |
| CO2 | 0.03 | N.M. | N.M. | N.M. | 1.03 |
| S | 0.01 | N.M. | N.M. | N.M. | 0.03 |
| Ti (ppm) | | 3956.04 | 5034.96 | 3896.1 | 5154.84 |
| Li | | 13.96 | 22 | 16 | 25 |
| Be | 0.01 | 2.45 | 1.48 | 1.1 | 2.02 |
| Sc | | 19.75 | 21.55 | 14.82 | 22 |
| V | | 164.4 | 158.19 | 110.69 | 179 |
| Cr | | 375 | 445 | 200 | 563 |
| Co | 1 | 28.6 | 50.62 | 29.31 | 43 |
| Ni | 3 | 83.1 | 178 | 124 | 120 |
| Cu | 3 | 77.6 | 55 | 5 | 52 |
| Zn | | 86.1 | 106 | 73 | 161 |
| Ga | | 15.5 | 18 | 19 | 17 |
| Rb | | 92 | 72.54 | 52.73 | 100.46 |
| Sr | | 792.00 | 812.60 | 1076.30 | 513.3 |
| Y | | 20.16 | 19.32 | 16.15 | 26.28 |
| Zr | | 116.80 | 142.40 | 142.30 | 177.5 |
| As | 1 | N.D. | 6.00 | 2.00 | 2 |
| Ag | | N.D. | 2.00 | 1.00 | 3 |
| Nb | | 3.96 | 5.00 | 4.90 | 5.8 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. | N.D. |
| Sn | | 1.08 | 5.00 | N.D. | N.D. |
| Cs | | 6.44 | 3.19 | 1.09 | 2.214 |
| Ba | | 2075.00 | 1269.00 | 1547.00 | 2059 |
| Hf | | 3.11 | 4.10 | 3.70 | 4.5 |
| Ta | | N.D. | 0.45 | 0.47 | 0.35 |
| W | | 0.34 | 23.00 | 21.00 | 8 |

| | | **01-BRB-0020** continued | **02-BRB-034** continued | **02-BRB-039** continued | **02-BRB-047** continued |
|---|---|---|---|---|---|
| | **Det. Limit** | | | | |
| Pb | 3 | 24.90 | 11.00 | 13.00 | 12 |
| Th | | 5.93 | 6.43 | 6.94 | 6.58 |
| U | | 1.42 | 1.75 | 1.83 | 2.016 |
| La | | 37.66 | 39.86 | 38.99 | 48.99 |
| Ce | | 78.95 | 80.46 | 74.37 | 105.89 |
| Pr | | 10.01 | 11.42 | 9.94 | 13.997 |
| Nd | | 39.21 | 46.03 | 37.42 | 58.18 |
| Sm | | 8.01 | 8.79 | 6.55 | 11.82 |
| Eu | | 2.24 | 2.28 | 1.82 | 2.951 |
| Gd | | 6.26 | 6.73 | 4.98 | 9.305 |
| Tb | | 0.82 | 0.91 | 0.67 | 1.127 |
| Dy | | 3.72 | 4.36 | 3.35 | 5.511 |
| Ho | | 0.71 | 0.84 | 0.63 | 0.987 |
| Er | | 1.62 | 2.10 | 1.68 | 2.584 |
| Tm | | N.D. | 0.32 | 0.26 | 0.349 |
| Yb | | 1.59 | 1.65 | 1.65 | 2.2 |
| Lu | | 0.22 | 0.28 | 0.26 | 0.319 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. | 3.63 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

N.M. = not measured

N.D. = not detected

**Table 5.** Geochemistry of alkalic metavolcanic and related intrusive rocks - Highway 66 area (cont'd).

| **Sample** | **Det. Limit** | **02-BRB-048** | **02-BRB-052** | **02-BRB-097** | **03-BRB-666** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 538032 | 537360 | 540297 | 560091 |
| **Northing** | | 5320978 | 5319891 | 5321194 | 5327555 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Holmes | Holmes/ Galer Lake | Holmes | Eby |
| **Rock Type** | | subvolc. alkalic intrus./flow | bedded mafic/intermed. tuff | schistose intermed. metavolc. rock | trachyte |
| SiO2 (wt.%) | | 59.8 | 51.67 | 56.70 | 60.29 |
| TiO2 | | 0.65 | 0.79 | 0.66 | 0.72 |
| Al2O3 | | 14.57 | 11.89 | 14.72 | 16.87 |
| Fe2O3 | | 5.47 | 11.54 | 6.46 | 5.61 |
| MnO | | 0.11 | 0.22 | 0.12 | 0.04 |
| MgO | | 5.2 | 7.39 | 5.98 | 3.10 |
| CaO | | 5.51 | 9.14 | 5.48 | 1.50 |
| Na2O3 | | 4.57 | 2.8 | 3.21 | 6.08 |
| K2O | | 2.36 | 2.16 | 3.26 | 1.92 |
| P2O5 | | 0.25 | 0.5 | 0.27 | 0.51 |
| LOI | | 1.6 | 1.83 | 2.49 | 2.83 |
| total | | **100.09** | **99.94** | **99.35** | **99.47** |
| CO2 | 0.03 | N.M. | N.M. | 0.34 | 0.78 |
| S | 0.01 | N.M. | N.M. | 0.01 | N.D. |
| Ti (ppm) | | 3896.1 | 4735.26 | 3956.04 | 4315.68 |
| Li | | 20 | 23 | 30 | 13 |
| Be | 0.01 | 1.19 | 1.72 | 0.78 | 0.93 |
| Sc | | 13.5 | 33.85 | 12.5 | 6.5 |
| V | | 109.59 | 205.12 | 111.9 | 84.4 |
| Cr | | 201 | 374 | 276 | 20 |
| Co | 1 | 28.26 | 53.73 | 29 | 15 |
| Ni | 3 | 116 | 96 | 121 | 13 |
| Cu | 3 | 24 | 21 | 16 | N.D. |
| Zn | | 87 | 168 | 117 | 39 |
| Ga | | 20 | 17 | 21 | 19 |
| Rb | | 54.09 | 69.57 | 79.75 | 39.79 |
| Sr | | 1045.00 | 925.80 | 634.3 | 215.7 |
| Y | | 14.40 | 23.94 | 16.3 | 17 |
| Zr | | 140.20 | 121.60 | 146.2 | 189 |
| As | 1 | 4.00 | 9.00 | N.D. | 1 |
| Ag | | 1.00 | 2.00 | 3 | N.D. |
| Nb | | 4.40 | 4.00 | 4.9 | 8.9 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. | N.D. |
| Cs | | 1.83 | 5.71 | 1.469 | 0.449 |
| Ba | | 1468.00 | 943.00 | 1437 | 606 |
| Hf | | 3.90 | 3.50 | 3.9 | 4.4 |
| Ta | | 0.43 | 0.41 | 0.32 | 0.54 |
| W | | 20.00 | 23.00 | 4 | 4 |
| | **Det. Limit** | **02-BRB-048** continued | **02-BRB-052** continued | **02-BRB-097** continued | **03-BRB-666** continued |
| Pb | 3 | 11.00 | 21.00 | 14 | N.D. |
| Th | | 7.18 | 4.56 | 6.58 | 11.36 |
| U | | 1.79 | 1.39 | 1.703 | 3.158 |
| La | | 43.63 | 32.01 | 45.04 | 56.72 |
| Ce | | 84.74 | 68.53 | 92.48 | 108.52 |
| Pr | | 11.60 | 10.23 | 11.159 | 12.114 |
| Nd | | 44.13 | 42.09 | 43.91 | 44.47 |
| Sm | | 7.33 | 8.80 | 7.59 | 7.39 |
| Eu | | 1.98 | 2.42 | 1.938 | 1.894 |
| Gd | | 5.40 | 7.53 | 5.487 | 5.182 |
| Tb | | 0.67 | 1.01 | 0.656 | 0.634 |
| Dy | | 3.10 | 5.00 | 3.274 | 3.349 |
| Ho | | 0.61 | 1.01 | 0.608 | 0.633 |
| Er | | 1.41 | 2.51 | 1.632 | 1.773 |
| Tm | | 0.23 | 0.38 | 0.223 | 0.266 |
| Yb | | 1.29 | 2.34 | 1.62 | 1.8 |
| Lu | | 0.21 | 0.35 | 0.213 | 0.272 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. | 129.77 |
| Pd | 2 | N.D. | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

N.M. = not measured

N.D. = not detected

**Table 6.** Geochemistry of mafic intrusive rocks - Highway 66 area.

| **Sample** | **Det. Limit** | **02-BRB-043** | **02-BRB-045** | **02-BRB-085** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 542883 | 543306 | 529904 |
| **Northing** | | 5318092 | 5318580 | 5311512 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Flavelle | Holmes | Cairo |
| **Rock Type** | | melanocratic gabbro | quartz diorite | gabbro |
| SiO2 (wt.%) | | 43.23 | 65.67 | 49.84 |
| TiO2 | | 1.42 | 0.79 | 2.43 |
| Al2O3 | | 9.07 | 15.51 | 13.16 |
| Fe2O3 | | 18.68 | 4.97 | 20.86 |
| MnO | | 0.27 | 0.08 | 0.31 |
| MgO | | 11.93 | 1.72 | 4.5 |
| CaO | | 11.47 | 3.05 | 3.44 |
| Na2O3 | | 0.75 | 5.80 | 3.38 |
| K2O | | 0.04 | 0.25 | 0.39 |
| P2O5 | | N.D. | 0.27 | 0.19 |
| LOI | | 2.69 | 1.76 | 2.65 |
| **total** | | **99.54** | **99.87** | **101.14** |
| CO2 | 0.03 | N.M. | 0.5 | N.M. |
| S | 0.01 | N.M. | N.D. | N.M. |
| Ti (ppm) | | 8511.48 | 4735.26 | 14565.42 |
| Li | | 12 | 8 | 19 |
| Be | 0.01 | N.D. | 0.72 | 0.29 |
| Sc | | >50.0( | 11.3 | 48.4 |
| V | | 303.79 | N.D. | >320.00 |
| Cr | | 104 | 10 | 15 |
| Co | 1 | 98.5 | 5 | 77.77 |
| Ni | 3 | 177 | N.D. | 38 |
| Cu | 3 | 78 | N.D. | 62 |
| Zn | | 109 | 35 | 183 |
| Ga | | 14 | 23 | 21 |
| Rb | | 0.52 | 3.04 | 5.69 |
| Sr | | 126.80 | 276.3 | 113.60 |
| Y | | 6.09 | 41.03 | 43.35 |
| Zr | | 15.20 | 265.1 | 141.10 |
| As | 1 | N.D. | N.D. | 2.00 |
| Ag | | 2.00 | N.D. | 2.00 |
| Nb | | 0.60 | 18.9 | 5.80 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 0.15 | 0.206 | 0.27 |
| Ba | | N.D. | 153 | 43.00 |
| Hf | | 0.50 | 6.3 | 4.10 |
| Ta | | 0.20 | 1.14 | 0.55 |
| W | | 17.00 | 10 | 24.00 |

| **Sample** | **Det. Limit** | **02-BRB-043** continued | **02-BRB-045** continued | **02-BRB-085** continued |
|---|---|---|---|---|
| Pb | 3 | N.D. | N.D. | N.D. |
| Th | | 0.10 | 2.16 | 0.75 |
| U | | 0.03 | 0.499 | 0.19 |
| La | | 1.63 | 27.21 | 7.75 |
| Ce | | 4.41 | 65.13 | 20.89 |
| Pr | | 0.72 | 8.835 | 3.30 |
| Nd | | 3.65 | 38.26 | 16.23 |
| Sm | | 1.12 | 7.76 | 4.67 |
| Eu | | 0.53 | 2.564 | 1.44 |
| Gd | | 1.37 | 7.76 | 6.40 |
| Tb | | 0.21 | 1.185 | 1.25 |
| Dy | | 1.24 | 7.133 | 7.99 |
| Ho | | 0.27 | 1.513 | 1.85 |
| Er | | 0.77 | 4.493 | 5.30 |
| Tm | | 0.12 | 0.638 | 0.88 |
| Yb | | 0.69 | 4.17 | 5.36 |
| Lu | | 0.12 | 0.654 | 0.93 |
| Au (ppb) | 6 | | N.D. | N.D. |
| Pd | 2 | | N.D. | N.D. |
| Pt | 1 | | N.D. | |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants
N.M. = not measured
N.D. = not detected

**Table 6.** Geochemistry of mafic intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **02-BRB-105** | **03-BRB-166** | **03-BRB-167** | **02-BRB-215** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 544866 | 563554 | 563168 | 529922 |
| **Northing** | | 5325938 | 5326793 | 5326377 | 5309898 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Burt | Eby | Eby | Cairo |
| **Rock Type** | | gabbro | quartz gabbro | leuco-grabbro | gabbro |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 47.62 | 51.37 | 48.60 | 44.39 |
| TiO2 | | 0.74 | 1.10 | 0.53 | 0.48 |
| Al2O3 | | 16.11 | 14.00 | 11.62 | 17.67 |
| Fe2O3 | | 11.59 | 13.60 | 11.78 | 9.93 |
| MnO | | 0.19 | 0.21 | 0.19 | 0.15 |
| MgO | | 7.39 | 6.58 | 11.58 | 10.17 |
| CaO | | 11.14 | 6.24 | 10.83 | 11.91 |
| Na2O3 | | 2.00 | 1.74 | 0.72 | 1.18 |
| K2O | | 0.82 | 0.74 | 0.24 | 0.28 |
| P2O5 | | 0.04 | 0.09 | 0.03 | 0.03 |
| LOI | | 2.28 | 4.34 | 3.73 | 3.2 |
| **total** | | **99.92** | **100.01** | **99.85** | **99.4** |
| CO2 | 0.03 | 0.26 | 1.23 | 0.87 | N.M. |
| S | 0.01 | 0.06 | N.D. | 0.01 | N.M. |
| Ti (ppm) | | 4435.56 | 6593.4 | 3176.82 | 2877.12 |
| Li | | 33 | 19 | 22 | 18 |
| Be | 0.01 | 0.24 | 0.4 | 0.16 | N.D. |
| Sc | | 31.9 | 35.1 | 47.5 | 22.09 |
| V | | 248.5 | 281.8 | 206.4 | 146.13 |
| Cr | | 419 | 106 | 494 | 488 |
| Co | 1 | 50 | 46 | 54 | 67.63 |
| Ni | 3 | 98 | 54 | 184 | 339 |
| Cu | 3 | 65 | 5 | 61 | 109 |
| Zn | | 81 | 82 | 84 | 75 |
| Ga | | 16 | 18 | 13 | 14 |
| Rb | | 35.43 | 13.61 | 5 | 8.47 |
| Sr | | 185.7 | 82.4 | 94 | 111.50 |
| Y | | 11.88 | 31.31 | 15 | 9.76 |
| Zr | | 33.8 | 88.1 | 25 | 27.40 |
| As | 1 | N.D. | 4 | 3 | N.D. |
| Ag | | 3 | 2 | 2 | 2.00 |
| Nb | | 1.3 | 3.3 | 0.9 | 1.20 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. | N.D. |
| Cs | | 1.345 | 0.426 | 0.265 | 0.33 |
| Ba | | 136 | 226 | 116 | 66.00 |
| Hf | | 1 | 2.5 | 0.8 | 0.90 |
| Ta | | N.D. | 0.24 | N.D. | 0.25 |
| W | | 5 | 4 | N.D. | 16.00 |

| | | **02-BRB-105** continued | **03-BRB-166** continued | **03-BRB-167** continued | **02-BRB-215** continued |
|---|---|---|---|---|---|
| | **Det. Limit** | | | | |
| Pb | 3 | 8 | 6 | N.D. | N.D. |
| Th | | 0.27 | 0.47 | 0.12 | 0.18 |
| U | | 0.14 | 0.113 | 0.03 | 0.06 |
| La | | 2 | 5.15 | 1.55 | 1.78 |
| Ce | | 4.9 | 13.87 | 4.08 | 4.85 |
| Pr | | 0.763 | 2.142 | 0.687 | 0.77 |
| Nd | | 3.75 | 10.78 | 3.57 | 3.87 |
| Sm | | 1.22 | 3.42 | 1.3 | 1.21 |
| Eu | | 0.589 | 1.166 | 0.558 | 0.49 |
| Gd | | 1.748 | 4.637 | 1.911 | 1.53 |
| Tb | | 0.299 | 0.824 | 0.356 | 0.33 |
| Dy | | 2.084 | 5.48 | 2.462 | 1.93 |
| Ho | | 0.465 | 1.222 | 0.547 | 0.44 |
| Er | | 1.396 | 3.711 | 1.696 | 1.41 |
| Tm | | 0.21 | 0.552 | 0.256 | 0.19 |
| Yb | | 1.41 | 3.67 | 1.65 | 1.14 |
| Lu | | 0.219 | 0.567 | 0.259 | 0.20 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. | |
| Pd | 2 | N.D. | N.D. | 16.45 | |
| Pt | 1 | 1.16 | N.D. | 14.35 | |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

N.M. = not measured

N.D. = not detected

**Table 6.** Geochemistry of mafic intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **02-BRB-252** | **03-BRB-470** | **03-BRB-621** | **03-BRB-649** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 531183 | 562116 | 544408 | 543219 |
| **Northing** | | 5311812 | 5327245 | 5324410 | 5317155 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Otto | Burt | Flavelle |
| **Rock Type** | | mafic flow/intrus. | mg gabbro | foliated gabbro/ diorite | gabbro |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 40.82 | 46.46 | 47.18 | 47.95 |
| TiO2 | | 2.5 | 0.64 | 1.12 | 0.35 |
| Al2O3 | | 16.07 | 9.93 | 14.50 | 15.21 |
| Fe2O3 | | 25.25 | 16.56 | 13.90 | 10.38 |
| MnO | | 0.28 | 0.22 | 0.21 | 0.16 |
| MgO | | 4.24 | 12.95 | 6.46 | 10.64 |
| CaO | | 2.92 | 7.81 | 12.14 | 10.04 |
| Na2O3 | | 5.16 | 0.50 | 1.47 | 0.76 |
| K2O | | 0.07 | 0.09 | 0.66 | 0.15 |
| P2O5 | | 0.44 | 0.02 | 0.06 | 0.02 |
| LOI | | 3.16 | 4.18 | 1.95 | 3.86 |
| **total** | | **100.91** | **99.36** | **99.65** | **99.52** |
| CO2 | 0.03 | N.M. | 0.32 | 0.25 | 0.26 |
| S | 0.01 | N.M. | N.D. | 0.07 | N.D. |
| Ti (ppm) | | 14985 | 3836.16 | 6713.28 | 2097.9 |
| Li | | 32 | 22 | 19 | 28 |
| Be | 0.01 | 0.7 | 0.17 | 0.34 | 0.13 |
| Sc | | >50. | 35.8 | 37.1 | 19.6 |
| V | | 184.66 | 202.2 | >320.0 | 99.4 |
| Cr | | N.D. | 663 | 243 | 320 |
| Co | 1 | 56.61 | 57 | 44 | 41 |
| Ni | 3 | 27 | 195 | 56 | 120 |
| Cu | 3 | 33 | 60 | 111 | N.D. |
| Zn | | 241 | 209 | 100 | 85 |
| Ga | | 30 | 16 | 20 | 13 |
| Rb | | 2.13 | N.D. | 26.99 | 3 |
| Sr | | 75.70 | 56 | 306.5 | 129 |
| Y | | 81.33 | 14 | 17.4 | 8 |
| Zr | | 242.90 | 28 | 39.6 | 17 |
| As | 1 | 1.00 | N.D. | N.D. | N.D. |
| Ag | | 2.00 | 2 | 2 | 2 |
| Nb | | 10.00 | 1.1 | 1.8 | 0.8 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. | N.D. |
| Cs | | 0.27 | 0.246 | 0.996 | 0.083 |
| Ba | | N.D. | 25 | 127 | 63 |
| Hf | | 6.60 | 0.9 | 1.2 | 0.6 |
| Ta | | 0.73 | N.D. | N.D. | N.D. |
| W | | N.D. | N.D. | N.D. | N.D. |

| | | **02-BRB-252** continued | **03-BRB-470** continued | **03-BRB-621** continued | **03-BRB-649** continued |
|---|---|---|---|---|---|
| | **Det. Limit** | | | | |
| Pb | 3 | N.D. | N.D. | 7 | N.D. |
| Th | | 1.25 | 0.14 | 0.24 | 0.14 |
| U | | 0.51 | 0.037 | 0.116 | 0.034 |
| La | | 9.78 | 1.74 | 3.19 | 1.97 |
| Ce | | 27.00 | 4.68 | 6.76 | 4.62 |
| Pr | | 4.75 | 0.79 | 1.041 | 0.682 |
| Nd | | 25.32 | 4.08 | 5.39 | 3.1 |
| Sm | | 8.66 | 1.32 | 1.82 | 0.89 |
| Eu | | 2.63 | 0.703 | 0.748 | 0.446 |
| Gd | | 12.27 | 1.804 | 2.542 | 1.17 |
| Tb | | 2.32 | 0.326 | 0.452 | 0.204 |
| Dy | | 14.27 | 2.236 | 3 | 1.409 |
| Ho | | 3.29 | 0.508 | 0.678 | 0.314 |
| Er | | 9.44 | 1.588 | 2.047 | 0.967 |
| Tm | | 1.45 | 0.237 | 0.296 | 0.152 |
| Yb | | 9.25 | 1.63 | 1.96 | 1.05 |
| Lu | | 1.45 | 0.251 | 0.31 | 0.163 |
| Au (ppb) | 6 | | N.D. | N.D. | N.D. |
| Pd | 2 | | N.D. | N.D. | 2.24 |
| Pt | 1 | | N.D. | N.D. | 5.99 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

N.M. = not measured

N.D. = not detected

**Table 7**. Geochemistry of the Cairo stock pluton.

| **Sample** | Det. Limit | **02-BRB-076** | **02-BRB-209** | **02-BRB-300** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 535605 | 531238 | 529822 |
| **Northing** | | 5316647 | 5316307 | 5315103 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Flavelle - McChesney property | Cairo | Cairo |
| **Rock Type** | | biotite-bearing syenite | sheared syenite | syenite |
| $SiO_2$ (wt.%) | | 57.86 | 62.25 | 63.17 |
| $TiO_2$ | | 0.54 | 0.53 | 0.35 |
| $Al_2O_3$ | | 13.24 | 15.54 | 16.05 |
| $Fe_2O_3$ | | 4.53 | 4.82 | 3.34 |
| MnO | | 0.1 | 0.06 | 0.06 |
| MgO | | 4.64 | 2.85 | 1.43 |
| CaO | | 4.69 | 2.48 | 2.02 |
| $Na_2O_3$ | | 3.71 | 4.53 | 6.47 |
| $K_2O$ | | 6.01 | 2.72 | 5.29 |
| $P_2O_5$ | | 0.44 | 0.32 | 0.16 |
| LOI | | 3.99 | 3.42 | 1.32 |
| total | | **99.76** | **99.52** | **99.66** |
| $CO_2$ | 0.03 | N.M. | 1.59 | N.M. |
| S | 0.01 | N.M. | N.D. | N.M. |
| Ti (ppm) | | 3236.76 | 3176.82 | 2097.9 |
| Li | | 61 | 25 | 16 |
| Be | 0.01 | 3.98 | 1.76 | 6.14 |
| Sc | | 11.27 | 5.5 | 4.95 |
| V | | 83.79 | 69.1 | 63.58 |
| Cr | | 192 | 46 | 41 |
| Co | 1 | 30.49 | 22 | 10.78 |
| Ni | 3 | 71 | 42 | 29 |
| Cu | 3 | N.D. | 27 | 21 |
| Zn | | 135 | 79 | 67 |
| Ga | | 20 | 24 | 25 |
| Rb | | >150.00 | 77.84 | >150.00 |
| Sr | | 732.60 | 119.8 | 872.90 |
| Y | | 14.86 | 13.99 | 19.13 |
| Zr | | 248.30 | 213.5 | 466.20 |
| As | 1 | 3.00 | N.D. | 2.00 |
| Ag | | 2.00 | N.D. | 1.00 |
| Nb | | 7.70 | 10.6 | 16.00 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | N.D. | |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 18.75 | 2.932 | 2.34 |
| Ba | | 2628.00 | 744 | 2545.00 |
| Hf | | 6.60 | 5.9 | 9.90 |
| Ta | | 0.38 | 0.72 | 0.85 |
| W | | 28.00 | 3 | N.D. |

| | Det. Limit | **02-BRB-076** continued | **02-BRB-209** continued | **02-BRB-300** continued |
|---|---|---|---|---|
| Pb | 3 | 25.00 | 11 | 36.00 |
| Th | | 17.38 | 17.87 | 26.53 |
| U | | 5.47 | 4.646 | 6.02 |
| La | | 81.76 | 32.88 | 69.13 |
| Ce | | 135.09 | 72 | 121.58 |
| Pr | | 17.57 | 9.086 | 15.16 |
| Nd | | 63.34 | 37.81 | 52.74 |
| Sm | | 10.10 | 7.91 | 8.57 |
| Eu | | 2.45 | 2.167 | 1.91 |
| Gd | | 6.97 | 5.709 | 5.81 |
| Tb | | 0.78 | 0.653 | 0.72 |
| Dy | | 3.12 | 2.949 | 3.24 |
| Ho | | 0.53 | 0.493 | 0.59 |
| Er | | 1.38 | 1.213 | 1.70 |
| Tm | | 0.19 | 0.163 | 0.25 |
| Yb | | 1.22 | 1.03 | 1.63 |
| Lu | | 0.21 | 0.144 | 0.26 |
| Au (ppb) | 6 | N.M. | N.D. | N.M. |
| Pd | 2 | N.M. | N.D. | N.M. |
| Pt | 1 | N.M. | N.D. | N.M. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 7**. Geochemistry of the Cairo stock pluton (cont'd).

| **Sample** | Det. Limit | **JAA-00-256** | **JAA-00-257** | **JAA-00-258** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 529277 | 529628 | 529567 |
| **Northing** | | 5318793 | 5315483 | 5313625 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Alma | Cairo | Cairo |
| **Rock Type** | | syenite | syenite | syenite |
| SiO2 (wt.%) | | 59.77 | 60.8 | 73.27 |
| TiO2 | | 0.37 | 0.41 | 0.4 |
| Al2O3 | | 16.27 | 16.31 | 13.01 |
| Fe2O3 | | 3.35 | 3.73 | 3.12 |
| MnO | | 0.05 | 0.07 | 0.04 |
| MgO | | 1.56 | 1.7 | 1.76 |
| CaO | | 2.9 | 1.91 | 0.34 |
| Na2O3 | | 5.51 | 6.44 | 6.35 |
| K2O | | 6.12 | 5.64 | 0.27 |
| P2O5 | | 0.23 | 0.17 | 0.07 |
| LOI | | 2.55 | 1.11 | 1.38 |
| total | | **98.68** | **98.29** | **100.01** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 2217.78 | 2457.54 | 2397.6 |
| Li | | 18.47 | 12.83 | 8.1 |
| Be | 0.01 | N.D. | 6 | N.D. |
| Sc | | 4 | 5 | 6 |
| V | | 62 | 73 | 62 |
| Cr | | 48.88 | 89.96 | 127.65 |
| Co | 1 | 9.19 | 6.58 | 10.37 |
| Ni | 3 | 24.16 | 34.58 | 31.97 |
| Cu | 3 | 74.88 | 23.25 | 113.62 |
| Zn | | 50.91 | 69.59 | 22.74 |
| Ga | | 21.65 | 22.53 | 13.1 |
| Rb | | 141.65 | 197.99 | 4.84 |
| Sr | | 729 | 604 | 91 |
| Y | | 10.14 | 17.27 | 5.43 |
| Zr | | 156.95 | 266.66 | 78.08 |
| As | 1 | 7.8 | N.D. | N.D. |
| Ag | | N.M. | N.M. | N.M. |
| Nb | | 7.16 | 16 | 3.8 |
| Mo | <1 | N.D. | 4.39 | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | 0.99 | 1.65 | 0.6 |
| Cs | | 2.79 | 1.91 | 0.18 |
| Ba | | 2463.2 | 2787.52 | 33.52 |
| Hf | | 4.41 | 7.88 | 2.47 |
| Ta | | 0.44 | 0.92 | 0.41 |
| W | | 7 | 2.44 | 0.38 |

| | Det. Limit | **JAA-00-256**<br>continued | **JAA-00-257**<br>continued | **JAA-00-258**<br>continued |
|---|---|---|---|---|
| Pb | 3 | 23.25 | 38.12 | 2.7 |
| Th | | 11.35 | 25.88 | 3 |
| U | | 2.52 | 4.77 | 0.95 |
| La | | 61.5 | 90.61 | 4.6 |
| Ce | | 115.1 | 156.68 | 10.83 |
| Pr | | 14.02 | 17.68 | 1.12 |
| Nd | | 49.21 | 60.79 | 4.26 |
| Sm | | 7.42 | 9.4 | 0.97 |
| Eu | | 1.56 | 2.12 | 0.25 |
| Gd | | 4.19 | 5.75 | 0.78 |
| Tb | | 0.44 | 0.65 | 0.14 |
| Dy | | 2.19 | 3.23 | 0.91 |
| Ho | | 0.36 | 0.59 | 0.19 |
| Er | | 0.87 | 1.42 | 0.59 |
| Tm | | 0.11 | 0.22 | 0.1 |
| Yb | | 0.7 | 1.33 | 0.66 |
| Lu | | 0.12 | 0.18 | 0.11 |
| Au (ppb) | 6 | 32.5 | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants
JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project
N.M. = not measured
N.D. = not detected

**Table 7**. Geochemistry of the Cairo stock pluton (cont'd).

| **Sample** | | **JAA-00-263** | **JAA-00-264** | **JAA-00-265** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 532084 | 535431 | 533465 |
| **Northing** | | 5312529 | 5321435 | 5321302 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Holmes | Alma |
| **Rock Type** | | sheared syenite | syenite | syenite |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 57 | 62.83 | 57.16 |
| TiO2 | | 0.36 | 0.34 | 0.38 |
| Al2O3 | | 12.08 | 15.39 | 15.36 |
| Fe2O3 | | 4.09 | 2.99 | 4.64 |
| MnO | | 0.1 | 0.04 | 0.09 |
| MgO | | 3.49 | 0.78 | 2.21 |
| CaO | | 7.56 | 2.04 | 3.37 |
| Na2O3 | | 3.34 | 4.87 | 6.7 |
| K2O | | 3.1 | 6.39 | 4.23 |
| P2O5 | | 0.22 | 0.18 | 0.32 |
| LOI | | 7.45 | 2.61 | 4.59 |
| total | | **98.79** | **98.46** | **99.05** |
| CO2 | 0.03 | N.M. | N.M. | N.M. |
| S | 0.01 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 2157.84 | 2037.96 | 2277.72 |
| Li | | 23.98 | 12.02 | 36.54 |
| Be | 0.01 | N.D. | N.D. | N.D. |
| Sc | | 8 | 5 | 6 |
| V | | 74 | 55 | 78 |
| Cr | | 226.86 | 101.95 | 139.5 |
| Co | 1 | 15.83 | 6.89 | 8.53 |
| Ni | 3 | 70.71 | 22.14 | 43.06 |
| Cu | 3 | 29.9 | 416.5 | 5.58 |
| Zn | | 57.46 | 44.7 | 111.45 |
| Ga | | 15.67 | 21.6 | 23.75 |
| Rb | | 64.34 | 186.94 | 180.03 |
| Sr | | 360 | 792 | 448 |
| Y | | 9.52 | 17.15 | 17.26 |
| Zr | | 99.12 | 258.96 | 167.18 |
| As | 1 | 9.46 | 3.76 | 10.76 |
| Ag | | N.M. | N.M. | N.M. |
| Nb | | 5.17 | 10.94 | 9.99 |
| Mo | <1 | 1.65 | 1.51 | 1.58 |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | 1.01 | 1.37 | 1.52 |
| Cs | | 1.04 | 2.08 | >5.00 |
| Ba | | 1644.26 | 3152.49 | 2194.81 |
| Hf | | 3.34 | 7.26 | 4.89 |
| Ta | | 0.34 | 0.61 | 0.47 |
| W | | 1.07 | 5.73 | 3.62 |

| | **Det. Limit** | **JAA-00-263** continued | **JAA-00-264** continued | **JAA-00-265** continued |
|---|---|---|---|---|
| Pb | 3 | 4.68 | 22.25 | 23.52 |
| Th | | 5.66 | 23.68 | 11.84 |
| U | | 1.83 | 3.14 | 4.41 |
| La | | 14.58 | 70.81 | 75.57 |
| Ce | | 28.24 | 134.58 | 149.21 |
| Pr | | 3.67 | 15.08 | 18.32 |
| Nd | | 15.32 | 56.06 | 66.1 |
| Sm | | 3.2 | 9.18 | 10.8 |
| Eu | | 0.82 | 2.08 | 2.47 |
| Gd | | 2.77 | 5.92 | 6.76 |
| Tb | | 0.34 | 0.64 | 0.74 |
| Dy | | 1.78 | 3.27 | 3.5 |
| Ho | | 0.36 | 0.54 | 0.63 |
| Er | | 0.97 | 1.46 | 1.51 |
| Tm | | 0.14 | 0.22 | 0.2 |
| Yb | | 0.88 | 1.24 | 1.51 |
| Lu | | 0.13 | 0.21 | 0.19 |
| Au (ppb) | 6 | N.D. | 39.06 | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 7**. Geochemistry of the Cairo stock pluton (cont'd).

| **Sample** | **Det. Limit** | **JAA-00-266** | **JAA-00-267** | **03-BRB-687** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 534884 | 536579 | 536624 |
| **Northing** | | 5319357 | 5315906 | 5319843 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Holmes | Flavelle | Holmes |
| **Rock Type** | | alkali granite | syenite | albitite - syenite |
| SiO2 (wt.%) | | 68.02 | 61.93 | 69.15 |
| TiO2 | | 0.23 | 0.58 | 0.29 |
| Al2O3 | | 14.98 | 16.79 | 15.34 |
| Fe2O3 | | 2.37 | 4.92 | 4.11 |
| MnO | | 0.04 | 0.05 | 0.04 |
| MgO | | 1.08 | 1.64 | 1.06 |
| CaO | | 0.23 | 1.93 | 1.71 |
| Na2O3 | | 5.1 | 2.96 | 4.60 |
| K2O | | 5.62 | 6.88 | 1.80 |
| P2O5 | | 0.07 | 0.31 | 0.12 |
| LOI | | 1.05 | 1.38 | 1.78 |
| total | | **98.79** | **99.37** | **100.00** |
| CO2 | 0.03 | N.M. | N.M. | 0.56 |
| S | 0.01 | N.M. | N.M. | 0.03 |
| Ti (ppm) | | 1378.62 | 3476.52 | 1738.26 |
| Li | | 14 | 16.77 | 14 |
| Be | 0.01 | 3 | N.D. | 0.64 |
| Sc | | 2 | 6 | 4.7 |
| V | | 29 | 90 | 7.3 |
| Cr | | 25.14 | 123.94 | 19 |
| Co | 1 | 4.4 | 3.15 | 5 |
| Ni | 3 | 13.08 | 32.22 | 8 |
| Cu | 3 | 4.05 | 6.72 | 24 |
| Zn | | 26.74 | 27.99 | 42 |
| Ga | | 21.24 | 25.51 | 18 |
| Rb | | >250.00 | >250.00 | 93.82 |
| Sr | | 107 | 276 | 224.9 |
| Y | | 14.66 | 25.92 | 26 |
| Zr | | 273.26 | 402.11 | 199 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | N.M. | N.M. | N.D. |
| Nb | | 19.47 | 18.37 | 7.7 |
| Mo | <1 | 1.16 | N.D. | N.D. |
| Cd | | N.D. | N.D. | |
| Sn | | 1.5 | 2.47 | N.D. |
| Cs | | 2.45 | >5.00 | 2.667 |
| Ba | | 463.86 | 2538.67 | 432 |
| Hf | | 10.51 | 10.68 | 5.4 |
| Ta | | 1.18 | 1.07 | 0.69 |
| W | | 4.6 | 48.84 | 7 |

| | **Det. Limit** | **JAA-00-266** continued | **JAA-00-267** continued | **03-BRB-687** continued |
|---|---|---|---|---|
| Pb | 3 | 13.27 | 13.01 | N.D. |
| Th | | 47.72 | 23.3 | 4.63 |
| U | | 6.74 | 2.29 | 1.108 |
| La | | 41.11 | >100.00 | 25.66 |
| Ce | | 57.5 | >200.00 | 52.77 |
| Pr | | 8.05 | >25.00 | 6.417 |
| Nd | | 28.14 | 94.99 | 25.2 |
| Sm | | 4.92 | 15.48 | 5.04 |
| Eu | | 1.24 | 3.51 | 1.271 |
| Gd | | 3.54 | 9.84 | 4.727 |
| Tb | | 0.45 | 1.11 | 0.747 |
| Dy | | 2.36 | 5.26 | 4.599 |
| Ho | | 0.47 | 0.94 | 0.957 |
| Er | | 1.25 | 2.19 | 2.862 |
| Tm | | 0.2 | 0.3 | 0.426 |
| Yb | | 1.32 | 1.69 | 2.89 |
| Lu | | 0.21 | 0.25 | 0.444 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 8.** Geochemistry of the Otto Stock.

| **Sample** | | **01-BRB-006B** | **03-BRB-144** | **03-BRB-145** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 573171 | 571892 | 572292 |
| **Northing** | | 5324800 | 5325965 | 5325616 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Otto | Otto |
| **Rock Type** | | hornblendite | melasyenite | melasyenite |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 41.84 | 50.47 | 53.28 |
| TiO2 | | 1.23 | 0.77 | 0.53 |
| Al2O3 | | 4.79 | 13.63 | 18.89 |
| Fe2O3 | | 15.33 | 8.57 | 6.88 |
| MnO | | 0.31 | 0.15 | 0.13 |
| MgO | | 9.58 | 5.53 | 2.14 |
| CaO | | 14.16 | 7.70 | 3.28 |
| Na2O3 | | 0.88 | 2.38 | 2.23 |
| K2O | | 3.38 | 6.74 | 9.40 |
| P2O5 | | 1.76 | 0.91 | 0.44 |
| LOI | | 5.65 | 2.63 | 2.31 |
| **total** | | **98.91** | **99.48** | **99.51** |
| CO2 | | N.M. | 1.4 | 0.96 |
| S | | N.M. | N.D. | 0.02 |
| Ti (ppm) | | 7372.62 | 4615.38 | 3176.82 |
| Li | | 16.4 | 54 | 84 |
| Be | 0.01 | 3.43 | 2.5 | 2.1 |
| Sc | | 36.1 | 17 | 5.2 |
| V | | 273.2 | 169.4 | 114.6 |
| Cr | | 299 | 154 | 47 |
| Co | 1 | 49.6 | 29 | 19 |
| Ni | | 107.5 | 45 | 13 |
| Cu | | 36 | 115 | 127 |
| Zn | | 172 | 146 | 137 |
| Ga | | 12.5 | 21 | 26 |
| Rb | | 82 | 192.22 | 269 |
| Sr | | 1576.00 | 1994.81 | 3026.39 |
| Y | | 46.60 | 30 | 25.12 |
| Zr | | 132.50 | 265 | 283.2 |
| As | 1 | | 11 | 3 |
| Ag | | | 3 | 3 |
| Nb | | 3.47 | 10.6 | 12 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | 99.48 | N.D. |
| Sn | | 2.37 | N.D. | N.D. |
| Cs | | 3.93 | 7.584 | 7.288 |
| Ba | | 2397.00 | 3411 | 4029 |
| Hf | | 4.81 | 8.4 | 7 |
| Ta | | N.D. | 0.6 | 0.75 |
| W | | 0.28 | 8 | 5 |
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | 11.00 | 28 | 17 |
| Th | | 10.20 | 18.5 | 9.88 |
| U | | 1.11 | 3.225 | 1.149 |
| La | | >250 | 135.67 | 107.69 |
| Ce | | >251 | 288.6 | 224.61 |
| Pr | | 72.79 | 35.4 | 26.91 |
| Nd | | 293.50 | 140.25 | 101.09 |
| Sm | | 48.54 | 24.38 | 17.36 |
| Eu | | 11.26 | 5.72 | 4.14 |
| Gd | | 32.79 | 15.894 | 11.664 |
| Tb | | 3.48 | 1.749 | 1.349 |
| Dy | | 11.99 | 7.797 | 5.91 |
| Ho | | 1.82 | 1.228 | 0.928 |
| Er | | 3.53 | 2.971 | 2.188 |
| Tm | | 0.40 | 0.372 | 0.268 |
| Yb | | 2.58 | 2.36 | 1.72 |
| Lu | | 0.44 | 0.327 | 0.251 |
| Au (ppb) | 6 | N.M. | N.D. | N.D. |
| Pd | 2 | N.M. | 4.17 | N.D. |
| Pt | 1 | N.M. | 3.34 | 1.28 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants
JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project
N.M. = not measured
N.D. = not detected

**Table 8.** Geochemistry of the Otto Stock (cont'd).

| **Sample** | | **03-BRB-330** | **03-BRB-440** | **03-BRB-451** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 567676 | 571527 | 565397 |
| **Northing** | | 5322279 | 5324233 | 5321391 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Otto | Otto |
| **Rock Type** | | alkalic granite | megacrystic syenite | mica-bearing alkali gabbro |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 67.46 | 62.66 | 48.38 |
| TiO2 | | 0.14 | 0.25 | 0.99 |
| Al2O3 | | 16.59 | 18.34 | 10.91 |
| Fe2O3 | | 1.52 | 2.50 | 10.41 |
| MnO | | 0.03 | 0.05 | 0.16 |
| MgO | | 0.65 | 0.74 | 11.33 |
| CaO | | 0.87 | 1.45 | 9.73 |
| Na2O3 | | 6.41 | 5.76 | 2.35 |
| K2O | | 4.90 | 6.21 | 2.96 |
| P2O5 | | 0.04 | 0.17 | 0.36 |
| LOI | | 0.58 | 1.01 | 1.87 |
| **total** | | **99.19** | **99.14** | **99.45** |
| CO2 | | 0.17 | 0.74 | 0.26 |
| S | | N.D. | 0.01 | N.D. |
| Ti (ppm) | | 839.16 | 1498.5 | 5934.06 |
| Li | | 15 | 10 | 61 |
| Be | 0.01 | 1.66 | 1.59 | 0.89 |
| Sc | | 1.5 | 2.7 | 23.6 |
| V | | 24.7 | 49.3 | 194.5 |
| Cr | | | 22 | 802 |
| Co | 1 | 4 | 7 | 43 |
| Ni | | 17 | 8 | 152 |
| Cu | | N.D. | 24 | 56 |
| Zn | | 46 | 52 | 101 |
| Ga | | | 25 | 19 |
| Rb | | 127 | 137 | 85.3 |
| Sr | | 392.3 | 1792.55 | 668.8 |
| Y | | 4.87 | 14.38 | 26 |
| Zr | | 84.7 | 116.2 | 62 |
| As | 1 | | 2 | N.D. |
| Ag | | N.D. | N.D. | 2 |
| Nb | | 3.6 | 8.6 | 7.1 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 4.939 | 2.236 | 3.651 |
| Ba | | | 2841 | 1075 |
| Hf | | 2.4 | 3.3 | 3.2 |
| Ta | | 0.25 | 0.42 | 0.39 |
| W | | 5 | 7 | N.D. |

| | | **03-BRB-330** | **03-BRB-440** | **03-BRB-451** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | 14 | 35 | N.D. |
| Th | | 4.63 | 15.55 | 2.18 |
| U | | 1.432 | 2.091 | 0.722 |
| La | | 8.91 | 60.77 | 28.18 |
| Ce | | 21.42 | 119.7 | 74.05 |
| Pr | | 2.525 | 13.577 | 10.965 |
| Nd | | 9.37 | 49.2 | 49.08 |
| Sm | | 1.69 | 8.01 | 9.93 |
| Eu | | 0.437 | 2.081 | 2.46 |
| Gd | | 1.23 | 5.217 | 7.736 |
| Tb | | 0.161 | 0.611 | 1.023 |
| Dy | | 0.838 | 2.843 | 5.376 |
| Ho | | 0.164 | 0.484 | 1.006 |
| Er | | 0.46 | 1.237 | 2.742 |
| Tm | | 0.069 | 0.161 | 0.372 |
| Yb | | 0.48 | 1.01 | 2.31 |
| Lu | | 0.076 | 0.133 | 0.323 |
| Au (ppb) | 6 | | N.D. | N.D. |
| Pd | 2 | | N.D. | 2.71 |
| Pt | 1 | | N.D. | 3.01 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 8.** Geochemistry of the Otto Stock (cont'd).

| **Sample** | | **03-BRB-575** | **03-BRB-577** | **03-BRB-605** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 569231 | 569552 | 564814 |
| **Northing** | | 5318937 | 5318986 | 5321332 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Otto | Otto |
| **Rock Type** | | syenite | pyroxenite | alkalic gabbro |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 65.32 | 49.82 | 49.09 |
| TiO2 | | 0.18 | 0.36 | 1.03 |
| Al2O3 | | 17.53 | 3.94 | 11.77 |
| Fe2O3 | | 2.28 | 10.54 | 10.44 |
| MnO | | 0.05 | 0.19 | 0.17 |
| MgO | | 1.13 | 17.66 | 10.75 |
| CaO | | 1.19 | 14.38 | 9.52 |
| Na2O3 | | 6.35 | 0.18 | 2.30 |
| K2O | | 4.63 | 0.20 | 2.13 |
| P2O5 | | 0.06 | 0.06 | 0.35 |
| LOI | | 0.81 | 2.06 | 1.73 |
| **total** | | **99.53** | **99.39** | **99.28** |
| CO2 | | 0.18 | 0.31 | 0.17 |
| S | | N.D. | 0.02 | N.D. |
| Ti (ppm) | | 1078.92 | 2157.84 | 6173.82 |
| Li | | 9 | 20 | 37 |
| Be | 0.01 | 1.49 | 0.27 | 0.67 |
| Sc | | 2.3 | 43.7 | 21.9 |
| V | | 30 | 135.4 | 186.5 |
| Cr | | | 1377 | 710 |
| Co | 1 | 6 | 72 | 45 |
| Ni | | 28 | 184 | 177 |
| Cu | | N.D. | 16 | 41 |
| Zn | | 58 | 81 | 110 |
| Ga | | | 7 | 18 |
| Rb | | 102.16 | 2.2 | 53.2 |
| Sr | | 683.2 | 179.4 | 640.6 |
| Y | | 8.96 | 10.64 | 22 |
| Zr | | 188.7 | 29.8 | 100 |
| As | 1 | | N.D. | N.D. |
| Ag | | N.D. | 2 | N.D. |
| Nb | | 4.9 | 1.1 | 5.9 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 1.79 | 0.172 | 1.765 |
| Ba | | | 73 | 861 |
| Hf | | 4.9 | 1 | 3.7 |
| Ta | | 0.29 | N.D. | 0.37 |
| W | | N.D. | N.D. | N.D. |

| | | **03-BRB-575** | **03-BRB-577** | **03-BRB-605** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | 5 | N.D. |
| Th | | 10.85 | 0.42 | 2.52 |
| U | | 2.13 | 0.151 | 0.712 |
| La | | 26.33 | 5.21 | 28.93 |
| Ce | | 48.88 | 13.28 | 68.16 |
| Pr | | 5.269 | 1.985 | 9.198 |
| Nd | | 18.99 | 9.2 | 39.8 |
| Sm | | 3.26 | 2.39 | 8.21 |
| Eu | | 0.823 | 0.703 | 2.165 |
| Gd | | 2.371 | 2.459 | 6.842 |
| Tb | | 0.306 | 0.368 | 0.919 |
| Dy | | 1.565 | 2.131 | 4.805 |
| Ho | | 0.291 | 0.426 | 0.899 |
| Er | | 0.806 | 1.151 | 2.452 |
| Tm | | 0.117 | 0.162 | 0.335 |
| Yb | | 0.77 | 1.08 | 2.12 |
| Lu | | 0.115 | 0.141 | 0.304 |
| Au (ppb) | 6 | | N.D. | 9.19 |
| Pd | 2 | | N.D. | N.D. |
| Pt | 1 | | N.D. | 2.55 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 8.** Geochemistry of the Otto Stock (cont'd).

| **Sample** | | **03-BRB-607** | **03-BRB-669** | **03-BRB-678** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 565458 | 566082 | 563351 |
| **Northing** | | 5320501 | 5320541 | 5323625 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Otto | Eby |
| **Rock Type** | | hornblendite | clinopyroxenite/ lamprophyre | pyroxenite |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 46.04 | 44.13 | 43.79 |
| TiO2 | | 1.18 | 1.36 | 1.45 |
| Al2O3 | | 8.97 | 10.47 | 6.10 |
| Fe2O3 | | 12.02 | 13.12 | 14.10 |
| MnO | | 0.18 | 0.19 | 0.29 |
| MgO | | 14.38 | 13.15 | 10.93 |
| CaO | | 11.81 | 11.49 | 15.26 |
| Na2O3 | | 1.28 | 2.33 | 1.49 |
| K2O | | 1.76 | 1.62 | 2.04 |
| P2O5 | | 0.27 | 0.51 | 1.91 |
| LOI | | 1.54 | 1.04 | 2.07 |
| **total** | | **99.43** | **99.41** | **99.43** |
| CO2 | | 0.3 | 0.09 | 0.36 |
| S | | 0.03 | 0.04 | 0.02 |
| Ti (ppm) | | 7072.92 | 8151.84 | 8691.3 |
| Li | | 30 | 20 | 74 |
| Be | 0.01 | 0.46 | 0.95 | 2.29 |
| Sc | | 27.1 | 30 | 30.7 |
| V | | 207.9 | 271.2 | 258.4 |
| Cr | | 1028 | 916 | 218 |
| Co | 1 | 51 | 53 | 56 |
| Ni | | 219 | 171 | 61 |
| Cu | | 77 | 82 | 159 |
| Zn | | 102 | 125 | 266 |
| Ga | | 16 | 18 | 20 |
| Rb | | 48.54 | 37.07 | 110.36 |
| Sr | | 368.5 | 556.4 | 918.9 |
| Y | | 23 | 28 | 54.82 |
| Zr | | 66 | 72 | 271.3 |
| As | 1 | N.D. | N.D. | 3 |
| Ag | | 2 | N.D. | 3 |
| Nb | | 4.9 | 5.7 | 13.6 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 1.274 | 1.424 | 5.868 |
| Ba | | 863 | 546 | 1359 |
| Hf | | 2.6 | 3.5 | 7.6 |
| Ta | | 0.32 | 0.34 | 0.58 |
| W | | N.D. | N.D. | N.D. |

| | | **03-BRB-607** continued | **03-BRB-669** continued | **03-BRB-678** continued |
|---|---|---|---|---|
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | N.D. | 8 |
| Th | | 1.2 | 1.2 | 20.55 |
| U | | 0.375 | 0.46 | 2.196 |
| La | | 17.33 | 26.37 | 278.31 |
| Ce | | 48.31 | 72.33 | 610.8 |
| Pr | | 7.443 | 10.894 | 69.84 |
| Nd | | 34.74 | 50.64 | 271.2 |
| Sm | | 7.9 | 10.99 | 45 |
| Eu | | 2.115 | 2.831 | 10.26 |
| Gd | | 6.851 | 8.99 | 29.07 |
| Tb | | 0.918 | 1.152 | 3.079 |
| Dy | | 4.965 | 6.041 | 13.078 |
| Ho | | 0.909 | 1.097 | 2.044 |
| Er | | 2.442 | 2.877 | 4.71 |
| Tm | | 0.318 | 0.375 | 0.568 |
| Yb | | 1.98 | 2.31 | 3.58 |
| Lu | | 0.282 | 0.323 | 0.518 |
| Au (ppb) | 6 | N.D. | 11.64 | 13.16 |
| Pd | 2 | 2.88 | 3.9 | 3.04 |
| Pt | 1 | 3.32 | 4.41 | 3.28 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants
JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project
N.M. = not measured
N.D. = not detected

**Table 8.** Geochemistry of the Otto Stock (cont'd).

| **Sample** | | **JAA-00-201** | **JAA-00-269** | **JAA-00-270** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 565144 | 565034 | 566447 |
| **Northing** | | 5321730 | 5324874 | 5322216 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Otto | Otto |
| **Rock Type** | | syenite - alkaline granite | syenite | syenite |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 65.03 | 62.09 | 66.45 |
| TiO2 | | 0.15 | 0.32 | 0.13 |
| Al2O3 | | 17.54 | 16.44 | 16.58 |
| Fe2O3 | | 1.86 | 3.2 | 1.41 |
| MnO | | 0.03 | 0.07 | 0.03 |
| MgO | | 0.87 | 1.43 | 0.6 |
| CaO | | 0.83 | 2.66 | 0.97 |
| Na2O3 | | 7.02 | 6.68 | 7.04 |
| K2O | | 4.84 | 5.43 | 5.2 |
| P2O5 | | 0.04 | 0.2 | 0.03 |
| LOI | | 0.5 | 0.54 | 0.52 |
| **total** | | **98.71** | **99.06** | **98.96** |
| CO2 | | N.M. | N.M. | N.M. |
| S | | N.M. | N.M. | N.M. |
| Ti (ppm) | | 899.1 | 1918.08 | 779.22 |
| Li | | 8.67 | 6.96 | 6.61 |
| Be | 0.01 | N.D. | N.D. | N.D. |
| Sc | | 2 | 2 | 2 |
| V | | 30 | 30 | 31 |
| Cr | | 32.73 | 38.41 | 36.86 |
| Co | 1 | 3.03 | 2.87 | 2.7 |
| Ni | | 16.68 | 19.21 | 18.03 |
| Cu | | 4.12 | 8.1 | 8.07 |
| Zn | | 27.76 | 23.1 | 21.95 |
| Ga | | 22.59 | 20.88 | 20.32 |
| Rb | | 118.63 | 94.43 | 90.35 |
| Sr | | 246 | 392 | 394 |
| Y | | 7.62 | 6.51 | 6.5 |
| Zr | | 156.85 | 82.68 | 83.02 |
| As | 1 | N.D. | 5.55 | 5.17 |
| Ag | | N.M. | N.M. | N.M. |
| Nb | | 6.67 | 3.36 | 3.37 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | 0.91 | 0.8 | 0.81 |
| Cs | | 0.92 | 0.82 | 0.82 |
| Ba | | 1217.63 | 1242.75 | 1240 |
| Hf | | 7.06 | 2.51 | 2.52 |
| Ta | | 0.47 | N.D. | N.D. |
| W | | 0.2 | 0.06 | 0.14 |

| | | **JAA-00-201** | **JAA-00-269** | **JAA-00-270** |
|---|---|---|---|---|
| | | continued | continued | continued |
| | **Det. Limit** | | | |
| Pb | 3 | 18.12 | 12.18 | 11.97 |
| Th | | 24.48 | 3.49 | 3.45 |
| U | | 5.73 | 1.04 | 1.07 |
| La | | 17.68 | 10.97 | 11.02 |
| Ce | | 34.33 | 25.18 | 24.33 |
| Pr | | 3.7 | 3.06 | 2.99 |
| Nd | | 12.65 | 11.18 | 11.05 |
| Sm | | 2.2 | 1.97 | 1.95 |
| Eu | | 0.57 | 0.5 | 0.46 |
| Gd | | 1.55 | 1.43 | 1.45 |
| Tb | | 0.21 | 0.18 | 0.19 |
| Dy | | 1.15 | 1.02 | 1.03 |
| Ho | | 0.22 | 0.2 | 0.21 |
| Er | | 0.66 | 0.54 | 0.59 |
| Tm | | 0.1 | 0.09 | 0.1 |
| Yb | | 0.71 | 0.55 | 0.51 |
| Lu | | 0.12 | 0.09 | 0.1 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 8.** Geochemistry of the Otto Stock (cont'd).

| **Sample** | | **JAA-00-271** | **JAA-00-272** | **JAA-00-273** | **JAA-00-274** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 568317 | 568416 | 570240 | 572583 |
| **Northing** | | 5321580 | 5320052 | 5320193 | 5320200 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Otto | Otto | Otto |
| **Rock Type** | | alkaline granite | syenite | quartz syenite | alkali granite |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 68.89 | 66.7 | 62.51 | 65.36 |
| TiO2 | | 0.12 | 0.19 | 0.21 | 0.17 |
| Al2O3 | | 15.82 | 17.33 | 17.32 | 16.62 |
| Fe2O3 | | 1.45 | 1.56 | 2.11 | 1.79 |
| MnO | | 0.03 | 0.04 | 0.05 | 0.03 |
| MgO | | 0.51 | 1.06 | 1.3 | 0.77 |
| CaO | | 0.81 | 0.72 | 2.67 | 1.33 |
| Na2O3 | | 6.8 | 7.17 | 7.32 | 7.34 |
| K2O | | 5.07 | 5.31 | 4.54 | 4.94 |
| P2O5 | | 0.03 | 0.07 | 0.07 | 0.05 |
| LOI | | 0.34 | 0.54 | 0.61 | 0.35 |
| **total** | | **99.87** | **100.69** | **98.71** | **98.75** |
| CO2 | | N.M. | N.M. | N.M. | N.M. |
| S | | N.M. | N.M. | N.M. | N.M. |
| Ti (ppm) | | 719.28 | 1138.86 | 1258.74 | 1018.98 |
| Li | | 7.35 | 4.03 | 5.7 | 23.38 |
| Be | 0.01 | N.D. | N.D. | N.D. | N.D. |
| Sc | | 2 | 3 | 3 | 2 |
| V | | 26 | 29 | 29 | 37 |
| Cr | | 34.37 | 62.66 | 50.32 | 7.94 |
| Co | 1 | 2.52 | 4.19 | 3.9 | 4.2 |
| Ni | | 17.23 | 29.84 | 25.67 | 6.28 |
| Cu | | 2.67 | 3.35 | 3.39 | 8.77 |
| Zn | | 28.46 | 26.71 | 30.85 | 27.6 |
| Ga | | 19.6 | 19.93 | 21.42 | 16.75 |
| Rb | | 109.71 | 67.8 | 68.33 | 74.86 |
| Sr | | 182 | 216 | 207 | 456 |
| Y | | 7.76 | 7.4 | 7.53 | 7.08 |
| Zr | | 163.71 | 26.27 | 26.14 | 122.72 |
| As | 1 | N.D. | 3.53 | N.D. | N.D. |
| Ag | | N.M. | N.M. | N.M. | N.M. |
| Nb | | 3.48 | 3.51 | 3.48 | 4.42 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. | N.D. |
| Sn | | 0.77 | 0.83 | 0.83 | 0.51 |
| Cs | | 1.81 | 0.41 | 0.45 | 0.41 |
| Ba | | 618.38 | 1155.06 | 1311.75 | 248.22 |
| Hf | | 3.65 | 1.04 | 1.04 | 4.21 |
| Ta | | N.D. | N.D. | N.D. | 0.31 |
| W | | 0.06 | 0.15 | 0.06 | N.D. |
| | | **JAA-00-271** continued | **JAA-00-272** continued | **JAA-00-273** continued | **JAA-00-274** continued |
| | **Det. Limit** | | | | |
| Pb | 3 | 12.99 | 4.55 | 13.08 | 3.87 |
| Th | | 3.19 | 1.22 | 1.21 | 8.82 |
| U | | 2.31 | 0.56 | 0.57 | 0.88 |
| La | | 11.79 | 12.09 | 12.35 | 16.14 |
| Ce | | 23.34 | 31.98 | 31.84 | 35.04 |
| Pr | | 2.73 | 3.33 | 3.32 | 3.93 |
| Nd | | 9.94 | 12.58 | 12.75 | 14.26 |
| Sm | | 1.81 | 2.41 | 2.41 | 2.34 |
| Eu | | 0.48 | 0.62 | 0.62 | 0.61 |
| Gd | | 1.38 | 1.7 | 1.73 | 1.67 |
| Tb | | 0.19 | 0.24 | 0.24 | 0.21 |
| Dy | | 1.1 | 1.32 | 1.34 | 1.27 |
| Ho | | 0.24 | 0.25 | 0.24 | 0.22 |
| Er | | 0.68 | 0.68 | 0.71 | 0.6 |
| Tm | | 0.11 | 0.11 | 0.1 | 0.1 |
| Yb | | 0.81 | 0.62 | 0.65 | 0.63 |
| Lu | | 0.14 | 0.09 | 0.08 | 0.1 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 9.** Geochemistry of intrusive rocks - Highway 66 area.

| **Sample** | | **02-BRB-083** | **02-BRB-104** | **03-BRB-197** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 527544 | 548748 | 550027 |
| **Northing** | | 5309378 | 5320382 | 5320652 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Burt | Burt |
| **Rock Type** | | tonalite - Round Lake batholith | tonalite - satellite intrusion to Round Lake batholith | granodiorite - satellite intrusion to Round Lake batholith |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 68.27 | 65.29 | 64.99 |
| TiO2 | | 0.32 | 0.37 | 0.36 |
| Al2O3 | | 15.29 | 15.01 | 15.32 |
| Fe2O3 | | 3.22 | 3.72 | 3.67 |
| MnO | | 0.03 | 0.07 | 0.07 |
| MgO | | 1.68 | 3.27 | 3.31 |
| CaO | | 1.26 | 3.22 | 3.5 |
| Na2O3 | | 6.8 | 4.28 | 4.78 |
| K2O | | 0.65 | 2.39 | 2.36 |
| P2O5 | | 0.09 | 0.19 | 0.18 |
| LOI | | 1.62 | 1.72 | 1.42 |
| **total** | | **99.23** | **99.53** | **99.96** |
| CO2 | 0.03 | N.M. | 0.46 | 0.24 |
| S | 0.01 | N.M. | N.D. | N.D. |
| Ti (ppm) | | 1918.08 | 2217.78 | 2157.84 |
| Li | | 9 | 17 | 14 |
| Be | 0.01 | 0.84 | 1.19 | 0.71 |
| Sc | | 4.48 | 6.9 | 5.6 |
| V | | 38.37 | 60.6 | 52.1 |
| Cr | | 18 | 147 | 134 |
| Co | 1 | 15.43 | 17 | 13 |
| Ni | 3 | 20 | 61 | 61 |
| Cu | 3 | N.D. | 12 | 5 |
| Zn | | 29 | 77 | 66 |
| Ga | | 19 | 20 | 19 |
| Rb | | 18 | 60.94 | 51.33 |
| Sr | | 368.8 | 541.1 | 570.9 |
| Y | | 3.79 | 8.62 | 7.25 |
| Zr | | 96.9 | 130.5 | 114.1 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | 1 | 2 | N.D. |
| Nb | | 2.8 | 3.7 | 3.1 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 0.45 | 1.318 | 0.604 |
| Ba | | 101 | 993 | 807 |
| Hf | | 2.8 | 3.6 | 3.1 |
| Ta | | 0.36 | 0.28 | 0.28 |
| W | | 25 | 7 | N.D. |

| | | **02-BRB-083** continued | **02-BRB-104** continued | **03-BRB-197** continued |
|---|---|---|---|---|
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | 11 | 7 |
| Th | | 2.42 | 5.49 | 3.99 |
| U | | 0.73 | 1.298 | 1.199 |
| La | | 15.08 | 30.44 | 28.33 |
| Ce | | 29.52 | 66.4 | 60.25 |
| Pr | | 3.7 | 8.43 | 7.515 |
| Nd | | 13.77 | 33.1 | 29.85 |
| Sm | | 2.26 | 5.42 | 4.92 |
| Eu | | 0.74 | 1.405 | 1.236 |
| Gd | | 1.37 | 3.539 | 3.047 |
| Tb | | 0.18 | 0.394 | 0.331 |
| Dy | | 0.82 | 1.804 | 1.536 |
| Ho | | 0.17 | 0.315 | 0.264 |
| Er | | 0.45 | 0.807 | 0.684 |
| Tm | | 0.06 | 0.11 | 0.092 |
| Yb | | 0.36 | 0.74 | 0.59 |
| Lu | | 0.07 | 0.105 | 0.086 |
| Au (ppb) | 6 | N.M. | N.D. | N.D. |
| Pd | 2 | N.M. | N.D. | N.D. |
| Pt | 1 | N.M. | 1.05 | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 9.** Geochemistry of intrusive rocks - Highway 66 area (cont'd).

| **Sample** | Det. Limit | **03-BRB-638** | **JAA-00-138** | **JAA-00-141** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 542787 | 550981 | 555811 |
| **Northing** | | 5315603 | 5316281 | 5320096 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Flavelle | Gross | Eby |
| **Rock Type** | | granodiorite - Round Lake batholith | tonalite gneiss- Round Lake batholith | granodiorite - Round Lake batholith |
| SiO2 (wt.%) | | 65.46 | 70.76 | 67.59 |
| TiO2 | | 0.61 | 0.2 | 0.27 |
| Al2O3 | | 16.6 | 15.77 | 15.75 |
| Fe2O3 | | 4.47 | 1.83 | 2.43 |
| MnO | | 0.08 | 0.02 | 0.04 |
| MgO | | 1.83 | 0.67 | 1.44 |
| CaO | | 4.8 | 3.09 | 2.34 |
| Na2O3 | | 2.43 | 5.12 | 5.94 |
| K2O | | 1.54 | 1.19 | 2.35 |
| P2O5 | | 0.15 | 0.05 | 0.09 |
| LOI | | 1.9 | 0.89 | 1.02 |
| **total** | | **99.87** | **99.59** | **99.26** |
| CO2 | 0.03 | 0.26 | N.M. | N.M. |
| S | 0.01 | 0.01 | N.M. | N.M. |
| Ti (ppm) | | 3656.34 | 1198.8 | 1618.38 |
| Li | | 21 | 19.13 | 11.27 |
| Be | 0.01 | 0.38 | N.D. | N.D. |
| Sc | | 6.4 | N.D. | 4 |
| V | | 47.8 | 20 | 39 |
| Cr | | 33 | 9.02 | 46.04 |
| Co | 1 | 10 | 4.09 | 6.53 |
| Ni | 3 | 14 | 6.08 | 23.89 |
| Cu | 3 | 16 | 3.31 | 9.86 |
| Zn | | 53 | 27.85 | 44.89 |
| Ga | | 18 | 17.42 | 20.61 |
| Rb | | 46.16 | 20.62 | 49.18 |
| Sr | | 253.2 | 402 | 522 |
| Y | | 11.05 | 0.83 | 4.36 |
| Zr | | 118.3 | 91.37 | 102.64 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | N.D. | N.M. | N.M. |
| Nb | | 4.8 | 1.04 | 2.38 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | 0.27 | 0.76 |
| Cs | | 1.336 | 0.45 | 0.68 |
| Ba | | 238 | 322.93 | 998.58 |
| Hf | | 2.9 | 2.83 | 3.04 |
| Ta | | 0.38 | 0.46 | 0.55 |
| W | | 3 | 0.09 | 0.07 |
| Pb | 3 | N.D. | 4.64 | 6.59 |
| Th | | 1.4 | 0.18 | 2.21 |
| U | | 0.326 | 0.11 | 0.55 |
| La | | 11.85 | 3.5 | 10.59 |
| Ce | | 25.94 | 7.03 | 23.22 |
| Pr | | 3.231 | 0.72 | 3 |
| Nd | | 13.25 | 2.51 | 12.2 |
| Sm | | 2.67 | 0.42 | 2.28 |
| Eu | | 0.94 | 0.31 | 0.56 |
| Gd | | 2.357 | 0.27 | 1.41 |
| Tb | | 0.338 | 0.03 | 0.17 |
| Dy | | 2.025 | 0.15 | 0.82 |
| Ho | | 0.407 | 0.03 | 0.16 |
| Er | | 1.173 | 0.08 | 0.41 |
| Tm | | 0.171 | 0.01 | 0.05 |
| Yb | | 1.12 | 0.08 | 0.37 |
| Lu | | 0.166 | 0.02 | 0.06 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 9.** Geochemistry of intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **JAA-00-251** | **JAA-00-277** | **03-BRB-612** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 532787 | 573273 | 538525 |
| **Northing** | | 5308981 | 5315697 | 5323040 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Cairo | Marquis | Holmes |
| **Rock Type** | | tonalite - Round Lake batholith | granodiorite - Round Lake batholith | massive diorite - intrusion central Holmes |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 68.07 | 70.32 | 67.18 |
| TiO2 | | 0.31 | 0.25 | 0.81 |
| Al2O3 | | 16.16 | 15.47 | 15.15 |
| Fe2O3 | | 2.49 | 2.3 | 5.03 |
| MnO | | 0.04 | 0.03 | 0.06 |
| MgO | | 1.33 | 0.8 | 2.13 |
| CaO | | 2.8 | 2.99 | 1.03 |
| Na2O3 | | 5.9 | 4.93 | 2.3 |
| K2O | | 1.52 | 1.22 | 2.6 |
| P2O5 | | 0.13 | 0.06 | 0.15 |
| LOI | | 1.05 | 0.9 | 2.83 |
| **total** | | **99.8** | **99.27** | **99.27** |
| CO2 | 0.03 | N.M. | N.M. | 0.18 |
| S | 0.01 | N.M. | N.M. | 0.1 |
| Ti (ppm) | | 1858.14 | 1498.5 | 4855.14 |
| Li | | 11.95 | 49.91 | 19 |
| Be | 0.01 | N.D. | N.D. | 0.51 |
| Sc | | 3 | 2 | 9.8 |
| V | | 37 | 24 | 116.1 |
| Cr | | 20.71 | >500.00 | 24 |
| Co | 1 | 6.8 | 46.25 | 11 |
| Ni | 3 | 15.6 | 226.04 | 14 |
| Cu | 3 | 6.58 | 65.58 | 40 |
| Zn | | 40.61 | 62.2 | 75 |
| Ga | | 21.57 | 17.02 | 18 |
| Rb | | 34.62 | 19.23 | 80.64 |
| Sr | | 575 | 292 | 156.8 |
| Y | | 5.69 | 2.46 | 12.85 |
| Zr | | 102.43 | 105.65 | 182.2 |
| As | 1 | N.D. | N.D. | N.D. |
| Ag | | N.M. | N.M. | N.D. |
| Nb | | 3.62 | 3.11 | 6.9 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | 0.55 | 0.66 | N.D. |
| Cs | | 0.36 | 0.35 | 2.768 |
| Ba | | 443.15 | 132.43 | 602 |
| Hf | | 3.51 | 3.31 | 4.6 |
| Ta | | 0.38 | 0.32 | 0.54 |
| W | | 0.08 | 0.41 | N.D. |
| | | **JAA-00-251** continued | **JAA-00-277** continued | **03-BRB-612** continued |
| | **Det. Limit** | | | |
| Pb | 3 | 10.88 | 3.59 | 6 |
| Th | | 3.91 | 1.76 | 2.45 |
| U | | 1.45 | 0.22 | 0.609 |
| La | | 26.52 | 17.83 | 11.66 |
| Ce | | 54.44 | 33.22 | 28.78 |
| Pr | | 6.78 | 3.73 | 3.551 |
| Nd | | 24.9 | 12.75 | 14.01 |
| Sm | | 3.74 | 1.87 | 2.76 |
| Eu | | 0.85 | 0.49 | 0.827 |
| Gd | | 2.11 | 1.1 | 2.46 |
| Tb | | 0.22 | 0.11 | 0.384 |
| Dy | | 1.13 | 0.49 | 2.372 |
| Ho | | 0.2 | 0.09 | 0.504 |
| Er | | 0.45 | 0.24 | 1.472 |
| Tm | | 0.07 | 0.03 | 0.222 |
| Yb | | 0.44 | 0.24 | 1.47 |
| Lu | | 0.07 | 0.04 | 0.223 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 9.** Geochemistry of intrusive rocks - Highway 66 area (cont'd).

| **Sample** | **Det. Limit** | **03-BRB-614** | **03-BRB-622** | **03-BRB-658** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 537407 | 542161 | 545392 |
| **Northing** | | 5325509 | 5326966 | 5324749 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Holmes | Holmes | Burt |
| **Rock Type** | | granodiorite - N. Holmes - part of Watabeag complex | fg granodiorite - part of Watabeag complex | qtz monzonite/ syenite - alkalic intrusion NW Burt |
| SiO2 (wt.%) | | 71.89 | 72.07 | 64.87 |
| TiO2 | | 0.1 | 0.07 | 0.32 |
| Al2O3 | | 15.54 | 15.89 | 15.93 |
| Fe2O3 | | 0.85 | 0.7 | 3.58 |
| MnO | | 0.02 | 0.02 | 0.07 |
| MgO | | 0.29 | 0.28 | 2.06 |
| CaO | | 1.04 | 0.54 | 2.57 |
| Na2O3 | | 5.74 | 6.03 | 5.03 |
| K2O | | 3.14 | 3.23 | 4.3 |
| P2O5 | | 0.04 | 0.02 | 0.21 |
| LOI | | 0.6 | 0.61 | 0.58 |
| **total** | | **99.25** | **99.46** | **99.52** |
| CO2 | 0.03 | 0.11 | 0.14 | 0.14 |
| S | 0.01 | N.D. | N.D. | N.D. |
| Ti (ppm) | | 599.4 | 419.58 | 1918.08 |
| Li | | 7 | 9 | 7 |
| Be | 0.01 | 1.15 | 0.86 | 1.96 |
| Sc | | 1 | 0.7 | 5.3 |
| V | | 7.3 | 4 | 51.7 |
| Cr | | 16 | 8 | 63 |
| Co | 1 | 4 | 2 | 11 |
| Ni | 3 | N.D. | N.D. | 26 |
| Cu | 3 | 5 | N.D. | 43 |
| Zn | | 28 | 19 | 57 |
| Ga | | 21 | 19 | 20 |
| Rb | | 74.53 | 71.88 | 119.95 |
| Sr | | 894.6 | 800 | 1136.2 |
| Y | | 2.44 | 2.46 | 14 |
| Zr | | 60.7 | 40.8 | 159 |
| As | 1 | N.D. | N.D. | 2 |
| Ag | | N.D. | N.D. | N.D. |
| Nb | | 2 | 1.4 | 7.8 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. |
| Sn | | N.D. | N.D. | N.D. |
| Cs | | 2.509 | 1.062 | 1.866 |
| Ba | | 1758 | 1950 | 1887 |
| Hf | | 2 | 1.3 | 5.6 |
| Ta | | N.D. | N.D. | 0.6 |
| W | | N.D. | N.D. | N.D. |

| | **Det. Limit** | **03-BRB-614** continued | **03-BRB-622** continued | **03-BRB-658** continued |
|---|---|---|---|---|
| Pb | 3 | 23 | 19 | 19 |
| Th | | 0.86 | 0.23 | 11.82 |
| U | | 0.8 | 0.453 | 2.935 |
| La | | 4.59 | 1.69 | 46.32 |
| Ce | | 10.95 | 4.55 | 88.85 |
| Pr | | 1.376 | 0.596 | 10.55 |
| Nd | | 5.48 | 2.45 | 39.41 |
| Sm | | 1.02 | 0.51 | 6.95 |
| Eu | | 0.265 | 0.143 | 1.606 |
| Gd | | 0.754 | 0.447 | 4.952 |
| Tb | | 0.088 | 0.065 | 0.599 |
| Dy | | 0.439 | 0.384 | 3.024 |
| Ho | | 0.082 | 0.08 | 0.541 |
| Er | | 0.229 | 0.241 | 1.491 |
| Tm | | 0.032 | 0.039 | 0.212 |
| Yb | | 0.24 | 0.29 | 1.39 |
| Lu | | 0.035 | 0.047 | 0.204 |
| Au (ppb) | 6 | N.D. | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | N.D. | N.D. | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 9.** Geochemistry of intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **03-BRB-477** | **03-BRB-487** | **JAA-00-202** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 564721 | 559583 | 562887 |
| **Northing** | | 5327463 | 5325759 | 5324178 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Eby | Eby |
| **Rock Type** | | lamprophyre dike | lamprophyre dike | bedded lamprophyric breccia |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 45.81 | 47.45 | 45.15 |
| TiO2 | | 0.82 | 0.67 | 0.89 |
| Al2O3 | | 13.77 | 11.98 | 10.18 |
| Fe2O3 | | 8.77 | 8.47 | 11.47 |
| MnO | | 0.14 | 0.18 | 0.18 |
| MgO | | 8.07 | 7.76 | 13.62 |
| CaO | | 5.58 | 9.16 | 8.49 |
| Na2O3 | | 5.05 | 2.15 | 2.13 |
| K2O | | 0.08 | 0.67 | 3.58 |
| P2O5 | | 0.37 | 0.84 | 0.48 |
| LOI | | 10.79 | 10.02 | 2.89 |
| **total** | | **99.25** | **99.35** | **99.06** |
| CO2 | 0.03 | 7.44 | 5.72 | N.M. |
| S | 0.01 | 0.48 | 0.04 | N.M. |
| Ti (ppm) | | 4915.08 | 4015.98 | 5334.66 |
| Li | | 20 | 28 | 53.21 |
| Be | 0.01 | 0.39 | 1.42 | N.D. |
| Sc | | 18.2 | 18.4 | 24 |
| V | | 165.5 | 134 | 198 |
| Cr | | 506 | 255 | >500.00 |
| Co | 1 | 34 | 32 | 47.5 |
| Ni | 3 | 111 | 84 | 328.09 |
| Cu | 3 | 54 | 9 | 70.7 |
| Zn | | 79 | 126 | 86.99 |
| Ga | | 16 | 16 | 13.22 |
| Rb | | N.D. | 23.8 | 101.87 |
| Sr | | 105 | 872.3 | 223 |
| Y | | 19 | 27 | 22.35 |
| Zr | | 107 | 197 | 80.87 |
| As | 1 | N.D. | 1 | N.D. |
| Ag | | N.D. | 2 | N.M. |
| Nb | | 4.5 | 7.6 | 10.71 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | | | N.D. |
| Sn | | N.D. | N.D. | 0.99 |
| Cs | | 0.26 | 2.201 | >5.00 |
| Ba | | N.D. | 3072 | 638.92 |
| Hf | | 2.9 | 5.8 | 2.57 |
| Ta | | 0.31 | 0.43 | 0.51 |
| W | | 4 | N.D. | 0.27 |
| | | **03-BRB-477** continued | **03-BRB-487** continued | **JAA-00-202** continued |
| | **Det. Limit** | | | |
| Pb | 3 | N.D. | N.D. | 3.94 |
| Th | | 2.93 | 13.01 | 3.83 |
| U | | 0.732 | 3.076 | 0.9 |
| La | | 22.19 | 81.69 | 33.69 |
| Ce | | 49.95 | 173.51 | 74.84 |
| Pr | | 6.452 | 21.55 | 10.03 |
| Nd | | 28.34 | 87.46 | 40.59 |
| Sm | | 5.89 | 15.96 | 7.4 |
| Eu | | 1.665 | 3.993 | 1.87 |
| Gd | | 5.131 | 11.232 | 5.65 |
| Tb | | 0.684 | 1.304 | 0.75 |
| Dy | | 3.852 | 6.075 | 4.04 |
| Ho | | 0.749 | 1.015 | 0.8 |
| Er | | 2.082 | 2.555 | 2.18 |
| Tm | | 0.297 | 0.345 | 0.31 |
| Yb | | 1.9 | 2.21 | 1.92 |
| Lu | | 0.281 | 0.312 | 0.3 |
| Au (ppb) | 6 | 6.62 | N.D. | N.D. |
| Pd | 2 | N.D. | N.D. | N.D. |
| Pt | 1 | 2.03 | 2.14 | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 9.** Geochemistry of intrusive rocks - Highway 66 area (cont'd).

| **Sample** | | **03-BRB-628** | **03-BRB-670** | **JAA-00-268** |
|---|---|---|---|---|
| **Easting (Zone 17)** | | 563587 | 549134 | 565916 |
| **Northing** | | 5324827 | 5318251 | 5326836 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 |
| **Township** | | Otto | Burt | Otto |
| **Rock Type** | | lamprophyric breccia - diatreme related to Otto stock | biotite-gabbro to lamprophyre | lamprophyre dike |
| | **Det. Limit** | | | |
| SiO2 (wt.%) | | 46.06 | 49.4 | 53.4 |
| TiO2 | | 0.87 | 0.68 | 0.59 |
| Al2O3 | | 11.47 | 11.41 | 11.93 |
| Fe2O3 | | 10.35 | 10.09 | 7.68 |
| MnO | | 0.17 | 0.16 | 0.15 |
| MgO | | 8.98 | 10.9 | 7.95 |
| CaO | | 10.48 | 10.12 | 7.73 |
| Na2O3 | | 2.68 | 1.75 | 4.77 |
| K2O | | 3.88 | 2.69 | 0.13 |
| P2O5 | | 0.54 | 0.4 | 0.4 |
| LOI | | 4.11 | 1.84 | 5.17 |
| **total** | | **99.59** | **99.44** | **99.9** |
| CO2 | 0.03 | 2.85 | 0.18 | N.M. |
| S | 0.01 | 0.15 | N.D. | N.M. |
| Ti (ppm) | | 5214.78 | 4075.92 | 3536.46 |
| Li | | 65 | 33 | 20.44 |
| Be | 0.01 | 1.63 | 1.17 | N.D. |
| Sc | | 20.8 | 25.7 | 5 |
| V | | 195.7 | 175.4 | 65 |
| Cr | | 399 | | 41.02 |
| Co | 1 | 45 | 42 | 6.72 |
| Ni | 3 | 218 | 137 | 15.22 |
| Cu | 3 | 60 | 31 | 38.38 |
| Zn | | 123 | 98 | 41.59 |
| Ga | | 15 | | 21.55 |
| Rb | | 116.53 | 116.9 | 129.04 |
| Sr | | 683.2 | 823.7 | 993 |
| Y | | 24.65 | 17.95 | 18.49 |
| Zr | | 116 | 97.4 | 153.61 |
| As | 1 | N.D. | | 6.25 |
| Ag | | 3 | N.D. | N.M. |
| Nb | | 10.3 | 3.2 | 9.27 |
| Mo | <1 | N.D. | N.D. | N.D. |
| Cd | | N.D. | | N.D. |
| Sn | | | | 1.18 |
| Cs | | 5.573 | 3.755 | 2.65 |
| Ba | | 2993 | | >3500.00 |
| Hf | | 3 | 2.6 | 4.5 |
| Ta | | 0.45 | 0.24 | 0.46 |
| W | | N.D. | N.D. | 0.88 |

| | | **03-BRB-628** continued | **03-BRB-670** continued | **JAA-00-268** continued |
|---|---|---|---|---|
| | **Det. Limit** | | | |
| Pb | 3 | 16 | N.D. | 17.89 |
| Th | | 4.44 | 3.67 | 12.12 |
| U | | 0.982 | 1.049 | 2.03 |
| La | | 42.68 | 26.88 | 74.83 |
| Ce | | 94.06 | 60.64 | 141.24 |
| Pr | | 11.918 | 7.937 | 16.59 |
| Nd | | 47.3 | 33.51 | 62 |
| Sm | | 8.52 | 6.84 | 10.23 |
| Eu | | 2.203 | 1.781 | 2.16 |
| Gd | | 6.715 | 5.433 | 6.07 |
| Tb | | 0.861 | 0.679 | 0.64 |
| Dy | | 4.697 | 3.614 | 3.38 |
| Ho | | 0.897 | 0.668 | 0.62 |
| Er | | 2.534 | 1.828 | 1.55 |
| Tm | | 0.352 | 0.25 | 0.21 |
| Yb | | 2.34 | 1.66 | 1.3 |
| Lu | | 0.345 | 0.245 | 0.2 |
| Au (ppb) | 6 | N.D. | 17.5 | N.D. |
| Pd | 2 | N.D. | 3.09 | N.D. |
| Pt | 1 | 1.82 | 3.34 | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 10.** Geochemistry of diabase dikes - Highway 66 area.

| **Sample** | | **02-BRB-060** | **03-BRB-160** | **03-BRB-161** | **03-BRB-568** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 526324 | 529164 | 533699 | 566596 |
| **Northing** | | 5312491 | 5310969 | 5312538 | 5327250 |
| **Township** | | Cairo | Cairo | Cairo | Otto |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Rock Type** | | diabase | medium-grained flow/dike | diabase/ gabbro | lo-mag suscept diabase |
| | **Det. Limit** | | | | |
| SiO2 (wt.%) | | 48.94 | 48.63 | 51.24 | 48.30 |
| TiO2 | | 0.87 | 1.09 | 0.84 | 0.97 |
| Al2O3 | | 12 | 15.47 | 12.56 | 14.83 |
| Fe2O3 | | 12.07 | 13.60 | 11.38 | 13.66 |
| MnO | | 0.36 | 0.35 | 0.17 | 0.20 |
| MgO | | 9.91 | 5.70 | 8.00 | 6.25 |
| CaO | | 8.55 | 8.14 | 9.10 | 9.12 |
| Na2O3 | | 1.6 | 3.32 | 2.18 | 2.25 |
| K2O | | 2.76 | 1.49 | 1.74 | 1.59 |
| P2O5 | | 0.39 | 0.13 | 0.14 | 0.10 |
| LOI | | 2.56 | 2.24 | 1.93 | 2.17 |
| total | | **100.01** | **100.16** | **99.28** | **99.44** |
| CO2 | 0.03 | N.M. | 0.13 | 0.28 | 0.2 |
| S | 0.01 | N.M. | 0.07 | 0.05 | 0.11 |
| Ti (ppm) | | 5214.78 | 6533.46 | 5034.96 | 5814.18 |
| Li | | 47 | 21 | 26 | 23 |
| Be | 0.01 | 0.94 | 0.4 | 0.47 | 0.36 |
| Sc | | 33.67 | 26.9 | 20.3 | 30.8 |
| V | | 250.55 | 253.8 | 193.2 | 250 |
| Cr | | 601 | 192 | 468 | 255 |
| Co | 1 | 51.86 | 39 | 52 | 48 |
| Ni | 3 | 140 | 71 | 196 | 62 |
| Cu | 3 | 23 | 140 | 75 | 151 |
| Zn | | 233 | 128 | 95 | 110 |
| Ga | | 15 | 19 | 17 | 18 |
| Rb | | 82.3 | 59 | 57 | 40.92 |
| Sr | | 321.10 | 324 | 332 | 127.6 |
| Y | | 21.98 | 26 | 14 | 24.19 |
| Zr | | 110.90 | 83 | 95 | 81.5 |
| As | 1 | 8.00 | N.D. | N.D. | N.D. |
| Ag | | 2.00 | 3 | 2 | 3 |
| Nb | | 4.10 | 5.1 | 4.8 | 4.3 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | | | | N.D. |
| Sn | | N.D. | N.D. | N.D. | N.D. |
| Cs | | 2.13 | 1.455 | 0.713 | 1.375 |
| Ba | | 997.00 | 447 | 778 | 187 |
| Hf | | 3.00 | 2.5 | 2.7 | 2.2 |
| Ta | | 0.40 | 0.36 | 0.28 | 0.31 |
| W | | 31.00 | N.D. | N.D. | 4 |

| | | **02-BRB-060** continued | **03-BRB-160** continued | **03-BRB-161** continued | **03-BRB-568** continued |
|---|---|---|---|---|---|
| | **Det. Limit** | | | | |
| Pb | 3 | 8.00 | 9 | 9 | N.D. |
| Th | | 4.58 | 1.5 | 3.52 | 1.36 |
| U | | 1.24 | 0.374 | 0.403 | 0.35 |
| La | | 29.27 | 9.53 | 19.8 | 8.91 |
| Ce | | 63.36 | 21.65 | 42.1 | 19.94 |
| Pr | | 9.03 | 2.885 | 5.186 | 2.625 |
| Nd | | 37.03 | 12.69 | 20.88 | 11.73 |
| Sm | | 7.81 | 3.41 | 4.22 | 3.04 |
| Eu | | 2.05 | 1.153 | 1.226 | 1.035 |
| Gd | | 6.20 | 4.192 | 3.836 | 3.81 |
| Tb | | 0.89 | 0.717 | 0.54 | 0.65 |
| Dy | | 4.48 | 4.659 | 3.015 | 4.248 |
| Ho | | 0.91 | 1.01 | 0.565 | 0.925 |
| Er | | 2.39 | 2.992 | 1.535 | 2.787 |
| Tm | | 0.36 | 0.443 | 0.207 | 0.407 |
| Yb | | 2.00 | 2.89 | 1.28 | 2.65 |
| Lu | | 0.35 | 0.439 | 0.181 | 0.41 |
| Au (ppb) | 6 | | N.D. | N.D. | N.D. |
| Pd | 2 | | 4.01 | 6.82 | 5.4 |
| Pt | 1 | | 5.45 | 7.23 | 10.15 |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 10.** Geochemistry of diabase dikes - Highway 66 area (cont'd).

| **Sample** | Det. Limit | **03-BRB-600** | **JAA-00-134** | **JAA-00-246** | **JAA-00-254** |
|---|---|---|---|---|---|
| **Easting (Zone 17)** | | 567204 | 523544 | 522619 | 527704 |
| **Northing** | | 5326544 | 5309799 | 5314375 | 5323136 |
| **Township** | | Otto | Powell | Powell | IR. 72 |
| **Datum** | | NAD 83 | NAD 83 | NAD 83 | NAD 83 |
| **Rock Type** | | diabase | diabase | diabase | diabase |
| SiO2 (wt.%) | | 46.92 | 48.74 | 48.78 | 49.74 |
| TiO2 | | 0.95 | 1.91 | 1.38 | 1.75 |
| Al2O3 | | 15.57 | 13.29 | 14.1 | 13.48 |
| Fe2O3 | | 13.66 | 15.7 | 16.01 | 17.26 |
| MnO | | 0.19 | 0.27 | 0.24 | 0.23 |
| MgO | | 6.33 | 5.59 | 5.58 | 4.67 |
| CaO | | 8.16 | 7.91 | 6.6 | 8.75 |
| Na2O3 | | 1.62 | 2.48 | 2.13 | 2.55 |
| K2O | | 2.82 | 2.31 | 3.71 | 0.89 |
| P2O5 | | 0.09 | 0.27 | 0.17 | 0.19 |
| LOI | | 2.67 | 1.73 | 1.72 | 0.87 |
| total | | **98.98** | **100.2** | **100.42** | **100.38** |
| CO2 | 0.03 | 0.17 | N.M. | N.M. | N.M. |
| S | 0.01 | 0.06 | N.M. | N.M. | N.M. |
| Ti (ppm) | | 5694.3 | 11448.5 | 8271.72 | 10489.5 |
| Li | | 23 | 14.74 | 27.19 | 11.1 |
| Be | 0.01 | 0.32 | N.D. | N.D. | N.D. |
| Sc | | 25.9 | 33 | 32 | 32 |
| V | | 226.9 | 333 | 267 | 399 |
| Cr | | 231 | 111.28 | 118.28 | 36.99 |
| Co | 1 | 43 | 42.11 | 47.9 | 51.22 |
| Ni | 3 | 88 | 60.79 | 55.36 | 46.55 |
| Cu | 3 | 147 | 160.79 | 176.24 | 177.81 |
| Zn | | 107 | 102.69 | 106.88 | 121.18 |
| Ga | | 19 | 16.89 | 19.04 | 18.68 |
| Rb | | 84 | 73.87 | 149.2 | 29.88 |
| Sr | | 513 | 250 | 335 | 142 |
| Y | | 23 | 39.54 | 36.84 | 37.31 |
| Zr | | 61 | 155.35 | 124.98 | 143.18 |
| As | 1 | N.D. | N.D. | 4.73 | N.D. |
| Ag | | 2 | N.M. | N.M. | N.M. |
| Nb | | 4.3 | 8.6 | 7.56 | 9.06 |
| Mo | <1 | N.D. | N.D. | N.D. | N.D. |
| Cd | | N.D. | N.D. | N.D. | N.D. |
| Sn | | N.D. | 1.18 | 1 | 1.39 |
| Cs | | 2.938 | 1.3 | 4.26 | 3.28 |
| Ba | | 571 | 532.95 | 1288.68 | 286.48 |
| Hf | | 2.2 | 4.39 | 3.85 | 4.44 |
| Ta | | 0.34 | 0.96 | 0.63 | 0.61 |
| W | | N.D. | 0.59 | 0.45 | 0.26 |

| | Det. Limit | **03-BRB-600** | **JAA-00-134** | **JAA-00-246** | **JAA-00-254** |
|---|---|---|---|---|---|
| Pb | 3 | 7 | 10.69 | 4.43 | 6.14 |
| Th | | 1.33 | 3.36 | 2.36 | 3.74 |
| U | | 0.345 | 0.84 | 0.6 | 0.91 |
| La | | 8.61 | 18.05 | 14.77 | 21.36 |
| Ce | | 19.32 | 38.22 | 32.46 | 43.46 |
| Pr | | 2.582 | 5.19 | 4.46 | 5.73 |
| Nd | | 11.54 | 22.44 | 19.31 | 23.91 |
| Sm | | 3 | 5.61 | 4.8 | 5.44 |
| Eu | | 1.013 | 1.64 | 1.38 | 1.6 |
| Gd | | 3.721 | 6.33 | 5.48 | 6.37 |
| Tb | | 0.636 | 1.02 | 0.93 | 1.04 |
| Dy | | 4.174 | 6.59 | 6.07 | 6.2 |
| Ho | | 0.909 | 1.46 | 1.36 | 1.39 |
| Er | | 2.693 | 4.14 | 3.92 | 3.97 |
| Tm | | 0.404 | 0.62 | 0.58 | 0.59 |
| Yb | | 2.61 | 4.08 | 3.68 | 3.95 |
| Lu | | 0.397 | 0.66 | 0.62 | 0.66 |
| Au (ppb) | 6 | N.D. | N.D. | 5.91 | N.D. |
| Pd | 2 | 6.1 | N.D. | 16.64 | N.D. |
| Pt | 1 | 8.8 | N.D. | 13.25 | N.D. |

BRB = samples collected 2002 to 2003 by B. R. Berger and assistants

JAA = samples collected 2000 by D. Robinson and S. Deschamps - Rock properties project

N.M. = not measured

N.D. = not detected

**Table 11.** Assay samples Highway 66 area*.

| Sample Number | Rock Type | Easting | Northing | Township | Ag (1 ppm)** | Cu (8 ppm) | Zn (2 ppm) | Ni (5 ppm) | Pb (3 ppm) | Au (6 ppb) | Pd (2 ppb) | Pt (1 ppb) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01-BRB-006a | hornblendite | 573171 | 5324800 | Otto | 2 | 114 | | 67 | 21 | N.D. | N.D. | N.D. |
| 01-BRB-006b | hornblendite | 573171 | 5324800 | Otto | | | | | | N.D. | 9.16 | N.D. |
| 01-BRB-015 | barite vein | 530660 | 5316972 | Cairo | N.D. | 11 | | 6 | 21 | N.D. | N.D. | N.D. |
| 01-BRB-016 | alkalic mafic flow | 538571 | 5317955 | Flavelle | | | | | | N.D. | N.D. | N.D. |
| 01-BRB-018 | subvolcanic alklaic intrusion | 538245 | 5320725 | Holmes | | | | | | 13.57 | N.D. | N.D. |
| 01-BRB-019 | alkalic clinopyroxenite | 563378 | 5323813 | Eby | 12 | 6830 | | 68 | 4 | 169.8 | 164.16 | 54.68 |
| 01-BRB-020 | trachyte dike | 564062 | 5327921 | Eby | | | | | | N.D. | N.D. | N.D. |
| 02-BRB-021 | grey quartz vein | 530559 | 5317537 | Cairo | 1 | 140 | 18 | 8 | | 80.93 | N.D. | 5.73 |
| 02-BRB-024 | Gowganda Sandstone | 535379 | 5310889 | Flavelle | 2 | 9 | 55 | 39 | 15 | N.D. | N.D. | N.D. |
| 02-BRB-025 | white quartz vein | 528414 | 5311819 | Cairo | N.D. | N.D. | 5 | 7 | | N.D. | N.D. | 2.29 |
| 02-BRB-030 | quartz + chlorite vein | 527096 | 5311289 | Cairo | N.D. | 13 | 6 | 15 | | N.D. | N.D. | 1.17 |
| 02-BRB-040 | pyritic syenite | 536890 | 5321273 | Holmes | 2 | 24 | 88 | 155 | | N.D. | N.D. | 3.73 |
| 02-BRB-054 | pyritic syenite | 537057 | 5319614 | Holmes | 2 | 1336 | 24 | 23 | | 21.36 | N.D. | 2.97 |
| 02-BRB-055 | pyritic wacke | 526394 | 5313177 | Cairo | 2 | 37 | 60 | 52 | | 32.91 | N.D. | N.D. |
| 02-BRB-067 | pyritic syenite | 534735 | 5314739 | Cairo | N.D. | 83 | 17 | 8 | | 529.24 | N.D. | 1.32 |
| 02-BRB-089 | pyritic intermediate schist | 533139 | 5326051 | Alma | 1 | 119 | 193 | 94 | | N.D. | N.D. | 15.77 |
| 02-BRB-093 | massive pyrite + quartz | 526615 | 5313333 | Cairo | 1 | 107 | 30 | 99 | | 11.86 | N.D. | N.D. |
| 02-BRB-107 | sulphide-rich calc-silicate alteration | 544718 | 5326582 | Burt | 3 | 499 | 44 | 79 | | 7.74 | N.D. | 1.27 |
| 02-BRB-110 | quartz + pyrite pod | 537198 | 5317342 | Flavelle | 5 | 89 | 22 | 20 | 87 | 1148 | N.D. | N.D. |
| 02-BRB-111 | quartz + chlorite pod | 537198 | 5317342 | Flavelle | 3 | 28 | 28 | 25 | 21 | 150.17 | N.D. | N.D. |
| 02-BRB-123 | pyrite in grey schist | 525342 | 5313234 | Cairo | 3 | 40 | 57 | 70 | 12 | 49.79 | N.D. | N.D. |
| 02-BRB-130 | magnetic gabbro | 529265 | 5309943 | Cairo | 3 | 212 | 125 | 15 | N.D. | N.D. | N.D. | N.D. |
| 02-BRB-132 | diabase | 529164 | 5310969 | Cairo | 8 | 371 | 55310 | N.D. | 3165 | 328.83 | N.D. | N.D. |
| 02-BRB-301 | quartz vein | 530962 | 5314592 | Cairo | N.D. | 226 | 17 | N.D. | 68 | N.D. | N.D. | N.D. |
| 02-GL-203 | quartz vein | 530724 | 5317194 | Cairo | 2 | 195 | 23 | 11 | | 19.82 | N.D. | N.D. |
| 02-GL-204 | pyritic komatiite | 531582 | 5311144 | Cairo | 4 | 68 | 82 | 20 | | 9.72 | N.D. | N.D. |
| 02-GL-205 | pyritic komatiite | 531582 | 5311144 | Cairo | N.D. | 68 | 130 | 18 | | N.D. | N.D. | N.D. |
| 02-GL-206 | sulphides with chlorite | 531920 | 5311119 | Cairo | 2 | 194 | 87 | 912 | | N.D. | 11.47 | 10.67 |
| 02-GL-207 | graphitic chert with pyrite | 531920 | 5311119 | Cairo | N.D. | 39 | 10 | 28 | | N.D. | N.D. | 1.42 |
| 02-GL-216 | pyritic diabase | 533793 | 5312392 | Cairo | 2 | 87 | 84 | 196 | | N.D. | 5.72 | 7.33 |
| 02-GL-219 | talc-chlorite schist | 530455 | 5310662 | Cairo | N.D. | N.D. | 55 | 1161 | | N.D. | N.D. | 2.71 |
| 02-GL-220 | chlorite schist | 530455 | 5310662 | Cairo | 2 | 117 | 171 | 86 | | 286.94 | 2.28 | 5.97 |
| 02-GL-221 | quartz vein | 530455 | 5310662 | Cairo | N.D. | N.D. | 19 | 17 | | N.D. | N.D. | 1.06 |
| 02-GL-222 | chlorite schist with pyrite | 530500 | 5310636 | Cairo | 4 | 102 | 222 | 22 | | 516.45 | N.D. | 2.75 |

*UTMs in NAD 83, Zone 17

Table 11. Assay samples Highway 66 area*.

| Sample Number | Rock Type | Easting | Northing | Township | Ag (1 ppm)** | Cu (8 ppm) | Zn (2 ppm) | Ni (5 ppm) | Pb (3 ppm) | Au (6 ppb) | Pd (2 ppb) | Pt (1 ppb) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 02-GL-224 | chlorite schist with pyrite | 530972 | 5312153 | Cairo | 1 | 26 | 65 | 69 |  | N.D. | N.D. | 1.5 |
| 02-GL-234 | chalcopyrite in basalt | 532150 | 5312284 | Cairo | 2 | 1288 | 102 | 36 |  | N.D. | N.D. | 2.59 |
| 02-GL-247 | chalcopyrite in quartz monzonite | 527423 | 5309226 | Cairo | 1 | 2040 | 86 | 79 | 5 | N.D. | N.D. | N.D. |
| 02-GL-250 | pyritic sandstone | 526497 | 5311371 | Cairo | 2 | 17 | 52 | 48 | 9 | 5.3 | N.D. | N.D. |
| 02-GL-252 | gabbro | 531183 | 5311812 | Cairo | 3 | 32 | 172 | N.D. | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-147 | hematized alkalic qtz porphyry | 562664 | 5327858 | Teck | N.D. | 65 | 54 | 38 | N.D. | 11.63 | N.D. | 1.61 |
| 03-BRB-151 | cherty lean iron formation | 562235 | 5323188 | Eby | N.D. | N.D. | 43 | 29 | N.D. | N.D. | N.D. | 1.27 |
| 03-BRB-163 | altered felsic dike? | 563779 | 5325909 | Eby | N.D. | 37 | 56 | 37 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-335 | pyritic conglomerate | 562205 | 5323305 | Eby | N.D. | 56 | 87 | 116 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-400 | basalt | 570552 | 5327555 | Otto | 2 | 103 | 108 | 110 | N.D. | N.D. | 2.24 | 2.95 |
| 03-BRB-426 | amphibole and pyrite rich dike | 572105 | 5326300 | Otto | 2 | 184 | 113 | 108 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-436 | magnetite iron formation | 573091 | 5325807 | Otto | 2 | 385 | 206 | 70 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-450 | mica rich alkalic gabbro | 565397 | 5321391 | Eby | 2 | 100 | 116 | 135 | N.D. | N.D. | 2.37 | 2.3 |
| 03-BRB-451 | feldspar rich alkalic rock | 565397 | 5321391 | Eby | 2 | 11 | 109 | 151 | N.D. | N.D. | 2.78 | 3.03 |
| 03-BRB-453 | hornblendite | 566392 | 5320160 | Eby | 2 | 23 | 89 | 196 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-458 | pyritic mafic/intermed metavolcanic | 569709 | 5327568 | Otto | 5 | 6847 | 610 | 57 | N.D. | 17.04 | 4.65 | N.D. |
| 03-BRB-464 | pyritic chert | 569372 | 5327583 | Otto | 2 | 404 | 596 | 90 | N.D. | N.D. | 3.34 | 2.26 |
| 03-BRB-477 | intermed volcanic with disseminated pyrite | 564717 | 5327446 | Otto | 3 | 273 | 472 | 82 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-478 | felsic volcanic with disseminated pyrite | 564394 | 5327065 | Otto | N.D. | 128 | 93 | 89 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-480 | int/felsic volcanic with disseminated pyrite | 564257 | 5327128 | Otto | 2 | 107 | 123 | 58 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-484 | magnetic, silicified, carbonatized volcanic | 559517 | 5325926 | Eby | N.D. | 161 | 94 | 21 | N.D. | 10.46 | N.D. | N.D. |
| 03-BRB-488 | pyrite-bearing mafic metavolcanic | 559710 | 5325573 | Eby | N.D. | 49 | 175 | N.D. | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-489 | carb+chlorite+py mafic volcanic | 559851 | 5325537 | Eby | 2 | 30 | 117 | 12 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-506 | basalt | 561336 | 5325776 | Eby | N.D. | 102 | 117 | 59 | N.D. | N.D. | N.D. | 1.2 |
| 03-BRB-523 | pyrite-bearing mafic metavolcanic | 574073 | 5318146 | Marquis | 4 | 1306 | 2750 | 169 | 31 | N.D. | N.D. | N.D. |
| 03-BRB-554 | siliceous metasedimentary rocks | 567056 | 5325717 | Otto | N.D. | 28 | 71 | 59 | N.D. | N.D. | N.D. | 1.45 |

*UTMs in NAD 83, Zone 17

**Table 11.** Assay samples Highway 66 area*.

| Sample Number | Rock Type | Easting | Northing | Township | Ag (1 ppm)** | Cu (8 ppm) | Zn (2 ppm) | Ni (5 ppm) | Pb (3 ppm) | Au (6 ppb) | Pd (2 ppb) | Pt (1 ppb) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03-BRB-561 | basalt | 558891 | 5326743 | Eby | N.D. | 7 | 34 | 459 | N.D. | N.D. | 2.24 | 3.63 |
| 03-BRB-615 | altered mafic schist | 555127 | 5324282 | Eby | N.D. | 81 | 106 | 58 | N.D. | N.D. | N.D. | 1.6 |
| 03-BRB-618 | pyritic argillite - gossan mat'l | 569317 | 5327569 | Otto | 2 | 228 | 414 | 229 | 11 | N.D. | 4.31 | 2.95 |
| 03-BRB-624 | altered mafic schist | 562775 | 5325564 | Eby | N.D. | 45 | 100 | 12 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-625 | carb altered feslic dike | 562875 | 5325615 | Eby | N.D. | N.D. | 16 | N.D. | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-632 | selected qtz vein mat'l from old shaft | 563608 | 5324476 | Otto | N.D. | 9 | 22 | 7 | N.D. | N.D. | N.D. | 1.16 |
| 03-BRB-633 | graphitic and siliceous qtz vn 5-7% py | 563608 | 5324476 | Otto | N.D. | 37 | 52 | 46 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-634 | qtz vn breccia - in place | 563608 | 5324476 | Otto | N.D. | N.D. | 33 | N.D. | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-635 | silicified and pyritic wall rock | 563608 | 5324476 | Otto | N.D. | 11 | 64 | 8 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-639 | rusty -cherty IF | 542845 | 5316017 | Flavelle | N.D. | 10 | 41 | N.D. | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-644 | selected samples of rusty chert | 543333 | 5316185 | Flavelle | N.D. | 6 | 18 | N.D. | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-647 | gabbro with disseminated pyrite | 543083 | 5317083 | Flavelle | 2 | 313 | 106 | 28 | N.D. | N.D. | N.D. | N.D. |
| 03-BRB-677 | basalt | 562230 | 5327888 | Eby | N.D. | 55 | 66 | 962 | N.D. | N.D. | N.D. | 1.12 |
| 03-BRB-679 | qtz vein | 563585 | 5323600 | Eby | 5 | 37 | 39 | 22 | 378 | N.D. | N.D. | N.D. |
| 03-BRB-682 | alkalic tuff | 536948 | 5316440 | Flavelle | 3 | 22 | 101 | 105 |  | 10.62 | N.D. | 2.3 |
| 03-BRB-686 | basalt | 562995 | 5325585 | Eby | N.D. | >6000 | 114 | 42 |  | N.D. | N.D. | N.D. |

*UTMs in NAD 83, Zone 17

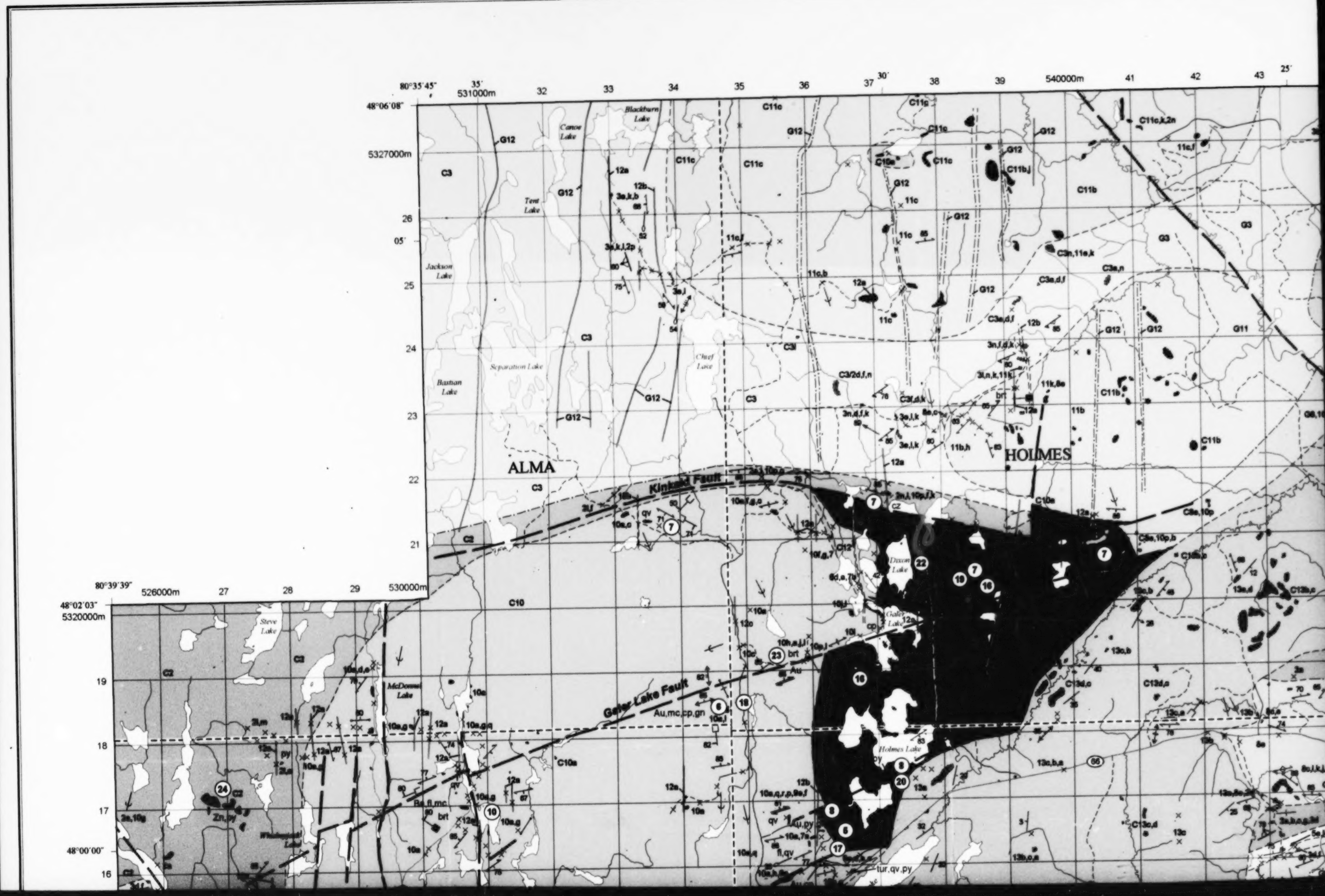
# Metric Conversion Table

| Conversion from SI to Imperial | | | Conversion from Imperial to SI | | |
|---|---|---|---|---|---|
| *SI Unit* | *Multiplied by* | *Gives* | *Imperial Unit* | *Multiplied by* | *Gives* |
| LENGTH | | | | | |
| 1 mm | 0.039 37 | inches | 1 inch | **25.4** | mm |
| 1 cm | 0.393 70 | inches | 1 inch | **2.54** | cm |
| 1 m | 3.280 84 | feet | 1 foot | **0.304 8** | m |
| 1 m | 0.049 709 | chains | 1 chain | 20.116 8 | m |
| 1 km | 0.621 371 | miles (statute) | 1 mile (statute) | **1.609 344** | km |
| AREA | | | | | |
| 1 cm$^2$ | 0.155 0 | square inches | 1 square inch | **6.451 6** | cm$^2$ |
| 1 m$^2$ | 10.763 9 | square feet | 1 square foot | **0.092 903 04** | m$^2$ |
| 1 km$^2$ | 0.386 10 | square miles | 1 square mile | 2.589 988 | km$^2$ |
| 1 ha | 2.471 054 | acres | 1 acre | 0.404 685 6 | ha |
| VOLUME | | | | | |
| 1 cm$^3$ | 0.061 023 | cubic inches | 1 cubic inch | **16.387 064** | cm$^3$ |
| 1 m$^3$ | 35.314 7 | cubic feet | 1 cubic foot | 0.028 316 85 | m$^3$ |
| 1 m$^3$ | 1.307 951 | cubic yards | 1 cubic yard | 0.764 554 86 | m$^3$ |
| CAPACITY | | | | | |
| 1 L | 1.759 755 | pints | 1 pint | 0.568 261 | L |
| 1 L | 0.879 877 | quarts | 1 quart | 1.136 522 | L |
| 1 L | 0.219 969 | gallons | 1 gallon | **4.546 090** | L |
| MASS | | | | | |
| 1 g | 0.035 273 962 | ounces (avdp) | 1 ounce (avdp) | 28.349 523 | g |
| 1 g | 0.032 150 747 | ounces (troy) | 1 ounce (troy) | **31.103 476 8** | g |
| 1 kg | 2.204 622 6 | pounds (avdp) | 1 pound (avdp) | **0.453 592 37** | kg |
| 1 kg | 0.001 102 3 | tons (short) | 1 ton (short) | **907.184 74** | kg |
| 1 t | 1.102 311 3 | tons (short) | 1 ton (short) | **0.907 184 74** | t |
| 1 kg | 0.000 984 21 | tons (long) | 1 ton (long) | **1016.046 908 8** | kg |
| 1 t | 0.984 206 5 | tons (long) | 1 ton (long) | **1.016 046 90** | t |
| CONCENTRATION | | | | | |
| 1 g/t | 0.029 166 6 | ounce (troy)/ ton (short) | 1 ounce (troy)/ ton (short) | 34.285 714 2 | g/t |
| 1 g/t | 0.583 333 33 | pennyweights/ ton (short) | 1 pennyweight/ ton (short) | 1.714 285 7 | g/t |

## OTHER USEFUL CONVERSION FACTORS

| | *Multiplied by* | |
|---|---|---|
| 1 ounce (troy) per ton (short) | 31.103 477 | grams per ton (short) |
| 1 gram per ton (short) | 0.032 151 | ounces (troy) per ton (short) |
| 1 ounce (troy) per ton (short) | 20.0 | pennyweights per ton (short) |
| 1 pennyweight per ton (short) | 0.05 | ounces (troy) per ton (short) |

*Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.*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48°00′00″
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Blackburn Lake
Canoe Lake
Tent Lake
Jackson Lake
Separation Lake
Bastian Lake
Chief Lake
Dixon Lake
Gafer Lake
Holmes Lake
Steve Lake
McDonnell Lake
ALMA
HOLMES
Kinkaid Fault
Gafer Lake Fault
C3
C2
C10
C10a
C11c
C11b
G12
G11
G3
12a
12b
Au,mc,cp,gn
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cz
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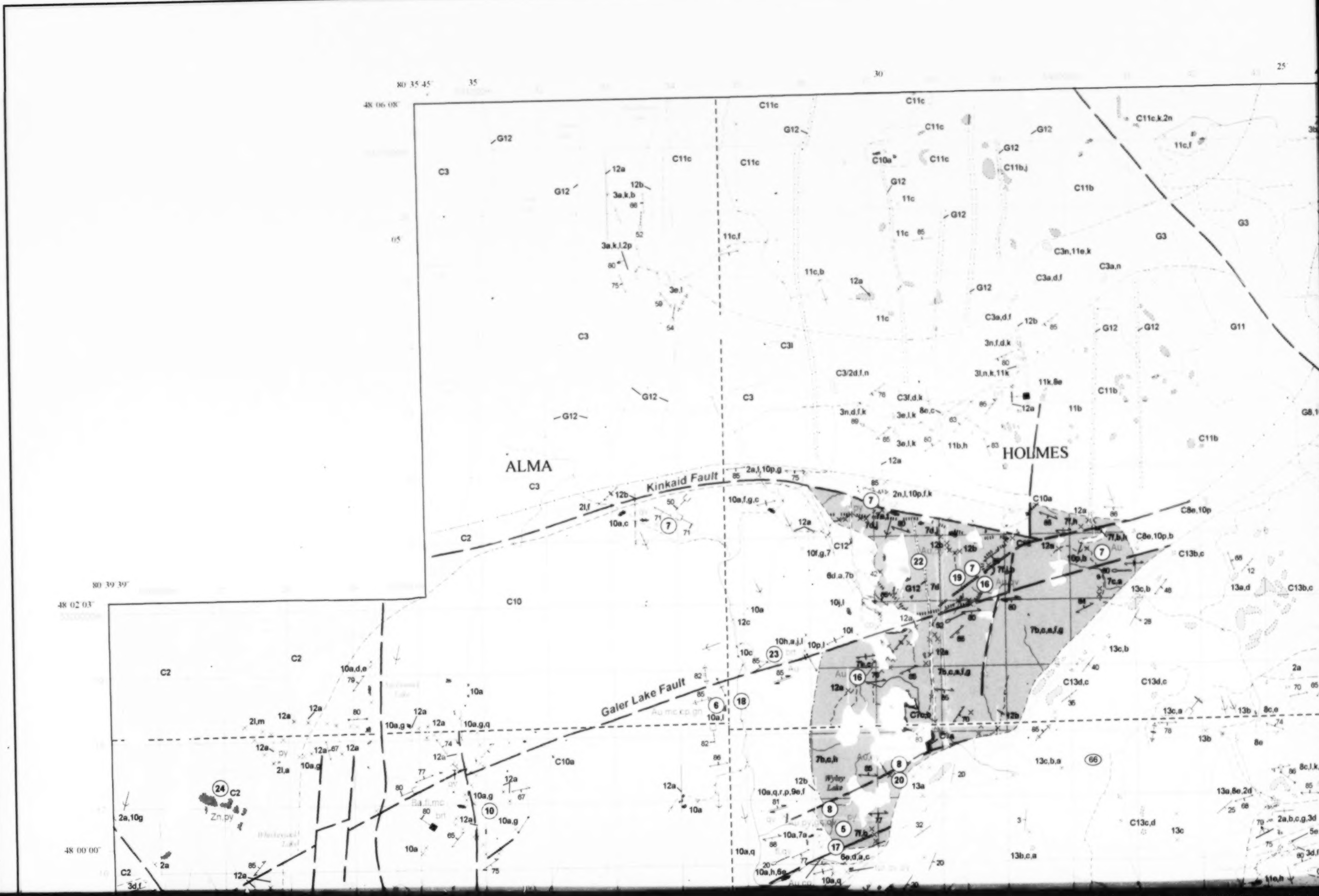
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C3
C2
C10
C10a
C11c
C11b
C11b,j
C11c,k,2n
C12
G12
G3
G11
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C3a,n
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C13c,d
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10a,g,q
10a,l
10a,q,r,p,9e,f
10a,7a
10a,h,6e
10a,q
7b,c,a,f,g
7b,c,h
7c,a
7l,b,h
13c,b
13c,b,a
13c,a
13b,c,a
13a,d
13a,8e,2d
2a,b,c,g,3d
8c,l,k,j
8c,e
8e,d,a,c
Au,mo,cp,gn
Ba,fl,mo
Zn,py
Wyber Lake
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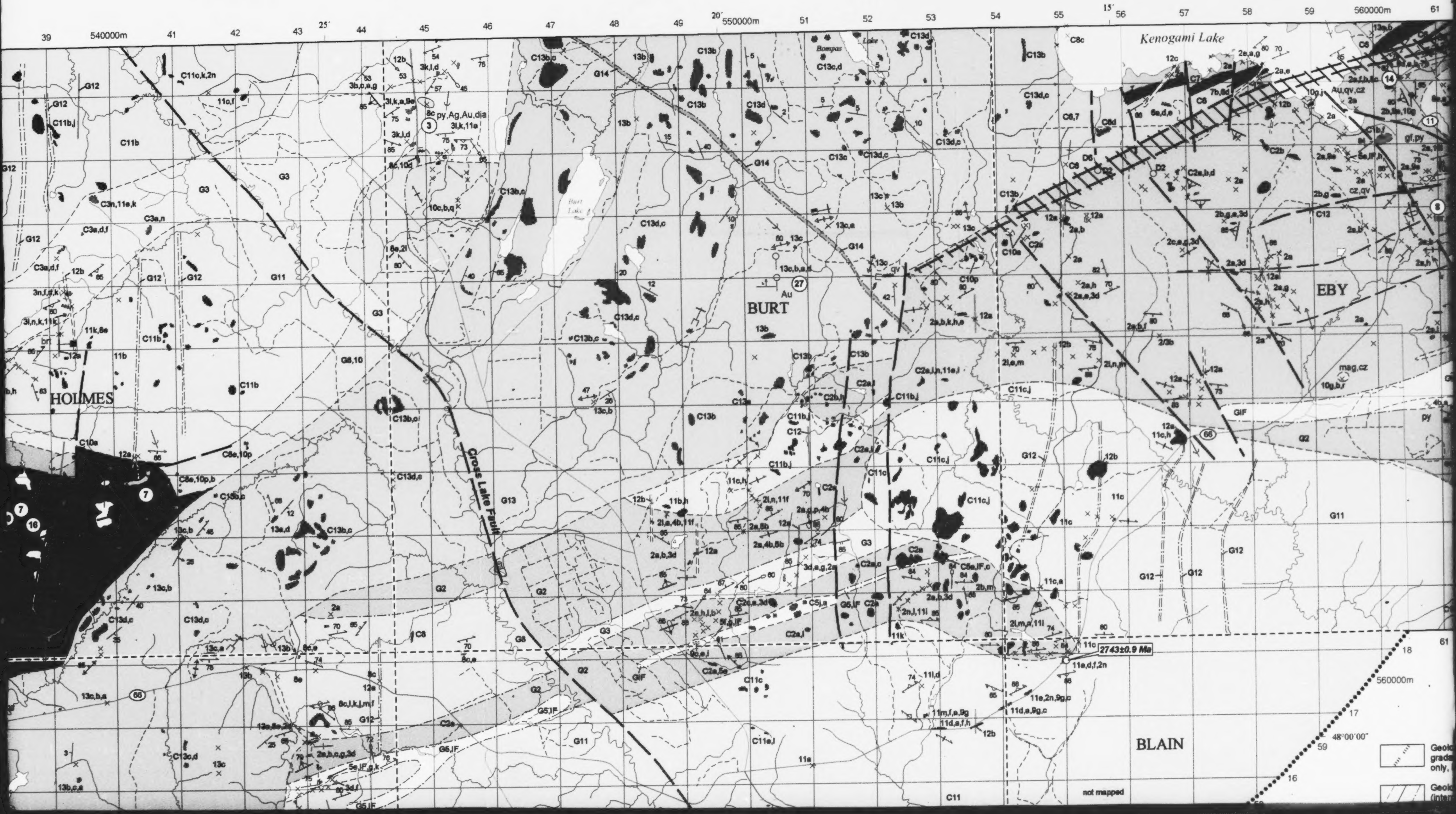
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Kenogami Lake
Bompas Lake
Burt Lake
HOLMES
BURT
EBY
BLAIN
Cross Lake Fault
C11c,k,2n
G12
C11b,j
C11b
C3n,11e,k
C3a,n
C3a,d,f
G3
G11
G8,10
G13
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C13b,c
C13b
C13d,c
C13c,d
C13d
C13c
13c,b,a,d
Au
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3l,k,11a
3k,l,d
12b
C10a
C8e,10p
C8e,10p,b
C8c
C8,7
C6d
C7
7b,8d
D6
D2
C2a,b,d
C2b
C12
C10p
C10e
2a,h
2a,e,3d
2a,b,k,h,e
C2a,l,n,11e,l
C11b,j
C11c,j
C11c
G12
G11
GIF
G2
11c,h
12a
2743±0.9 Ma
11e,d,f,2n
11e,2n,9g,c
11d,a,9g,c
11m,f,a,9g
11d,a,f,h
C2a,c
C5a,IF,c
C5j,a
G5,IF
2n,l,11l
11k
C2a,5e
C11c
C11e,l
C13c,d
13c,b,a
13b,c,a
2a,b,c,g,3d
5e,IF,g,k
G5,IF
C3a
C8
8c,e
11a
C11
not mapped
Au,qv,cz
gf,py
mag,cz
10g,b,f
2b,g,a,3d
2c,a,g,3d
2a,3d
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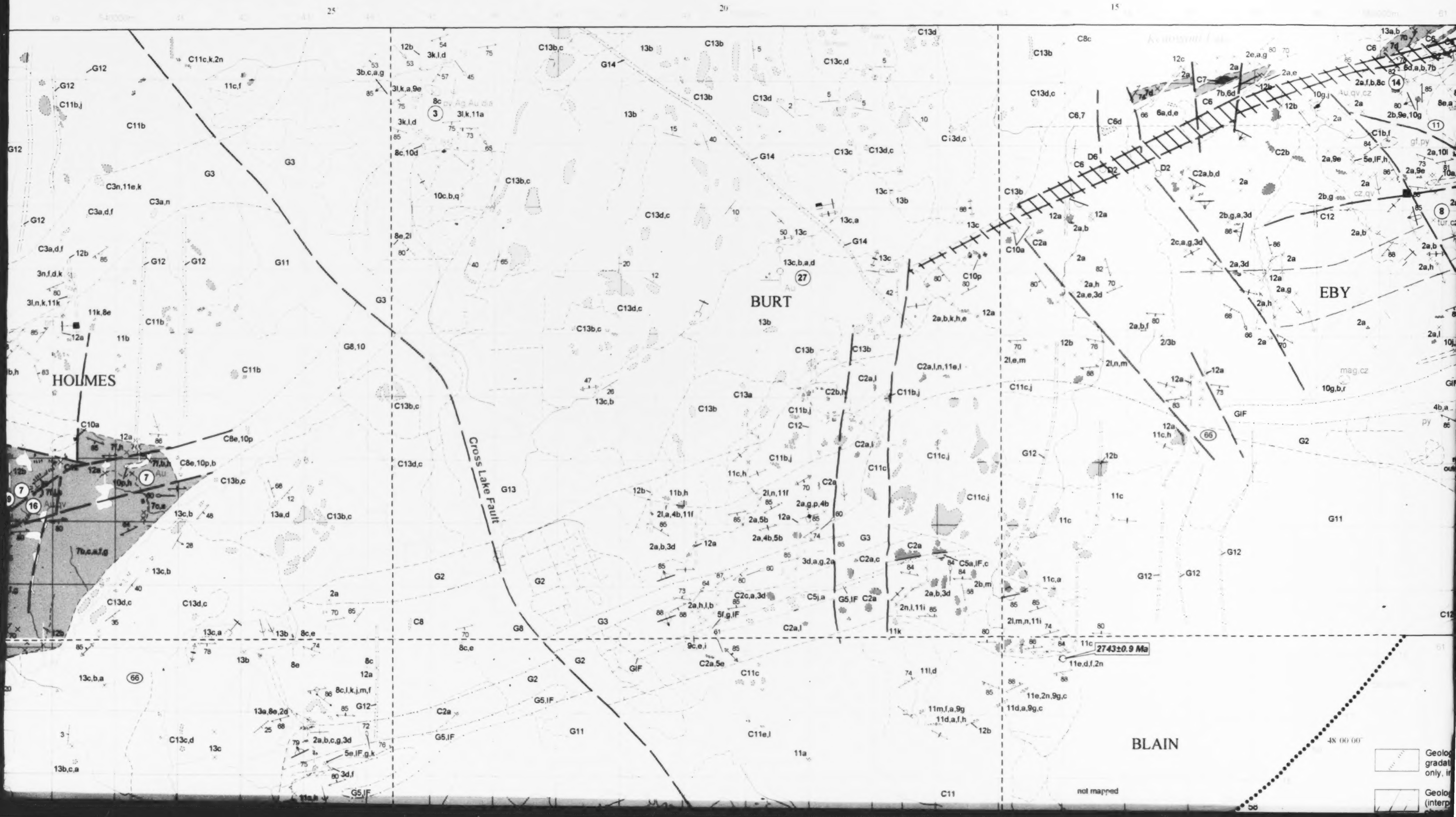
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HOLMES
BURT
EBY
BLAIN
Cross Lake Fault
2743±0.9 Ma
11e,d,f,2n
not mapped
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G3
G2
G8
G13
G14
GIF
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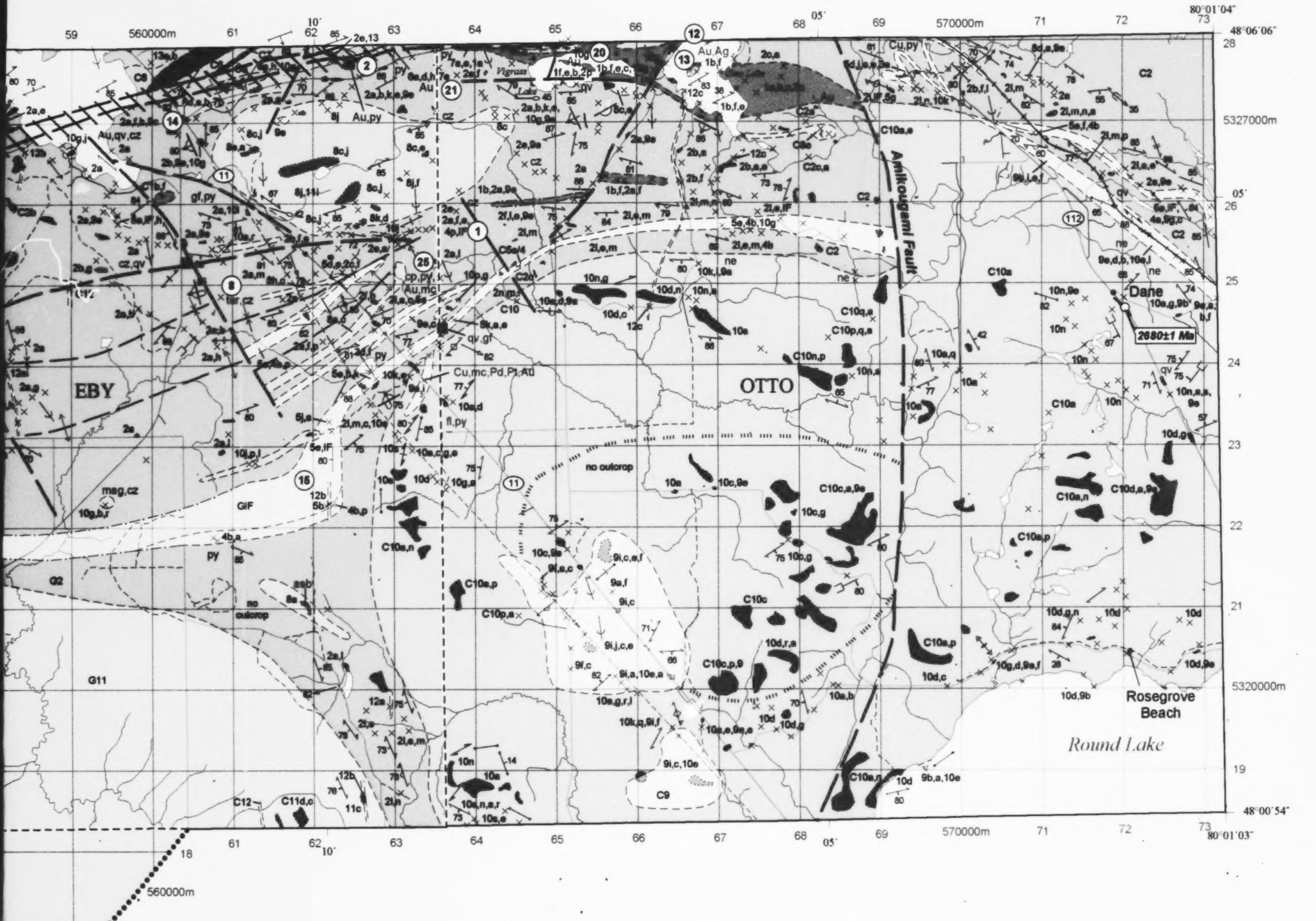

# LEGEND[ab]

## PHANEROZOIC

### CENOZOIC

### QUATERNARY

RECENT
Lake, stream and wetland deposits

PLEISTOCENE
Glacial, glaciofluvial and glaciolacustrine deposits: sand, gravel, clay, till

*UNCONFORMITY*

## PRECAMBRIAN

## PROTEROZOIC

### MESOPROTEROZOIC

**14** **Mafic Intrusive Rocks:** diabase dikes (Sudbury swarm)

*INTRUSIVE CONTACT*

### PALEOPROTEROZOIC

**HURONIAN SUPERGROUP**

**Cobalt Group**

**13** **Gowganda Formation**
- 13a Conglomerate
- 13b Sandstone and arkose
- 13c Siltstone and argillite
- 13d Wacke

*UNCONFORMITY*

**12** **Mafic Intrusive Rocks (Diabase Dikes)**
- 12a Diabase: <1% plagioclase phenocrysts (Matachewan swarm)
- 12b Diabase: >1% plagioclase phenocrysts (Matachewan swarm)
- 12c Diabase: medium-grained, equigranular, unknown affinity

*INTRUSIVE CONTACT*

## ARCHEAN

### NEOARCHEAN

**11** **Metamorphosed Calc-Alkalic Felsic and Intermediate Intrusive Rocks**
- 11a Massive to foliated tonalite
- 11b Massive to foliated monzonite and quartz monzonite
- 11c Massive to foliated granodiorite, granite
- 11d Gneiss: compositional mineral layering
- 11e Gneiss: banded and injection
- 11f Aplite and/or pegmatite dikes
- 11h Xenolith-bearing: 1 to 10% generally small (<30 cm in size) country rock
- 11i Equigranular to feldspar porphyritic tonalite dikes
- 11j Feldspar porphyritic granodiorite
- 11k Agmatitic-textured tonalite gneiss with rounded to angular mafic inclusions up to 40 cm in size
- 11l Tonalitic to dioritic metatexite: *in situ*, has melanosome rims around leucosome
- 11m Dioritic to tonalitic diatexite: medium-grained, homogeneous

**10** **Metamorphosed Alkalic Felsic and Intermediate Intrusive Rocks**
- 10a Equigranular, medium- to coarse-grained syenite
- 10b Monzonite, quartz monzonite

## SYMBOLS

Geological contact, gradational, trend only, interpreted

Geological contact (interpreted, observed, interpreted

Graded bedding, with facing (inclined, vertical, overturned)

Sedimentary bedding, facing known from other than grading or

Compositional layering and parallel tectonic foliation, unknown generation (inclined, vertical, trend only)

Reverse brittle-ductile fault, unknown horizontal displacement and generation, inclined

Shear zone, dextral

## PROPERTIES[a]

1. Allsopp, A. (Au, Cu) [2004]
2. Baldwin Consolidated Mines Limited (Au) [1946]
3. Bastarache, G. (Ag, Au, Cu) [2004]
4. Biralger Resources Limited (Au, Cu) [1996]
5. Brigadier Gold Limited (Au, Ag) [2004]
6. Brookbank Property (Au, Pb, Cu) [1914]
7. Cunningham, L. (Au) [1985-2004]

# LEGEND[ab]

## PHANEROZOIC

### CENOZOIC

QUATERNARY

RECENT
Lake, stream and wetland deposits

PLEISTOCENE
Glacial, glaciofluvial and glaciolacustrine deposits: sand, gravel, clay, till

*UNCONFORMITY*

## PRECAMBRIAN

### PROTEROZOIC

MESOPROTEROZOIC

**14** **Mafic Intrusive Rocks:** diabase dikes (Sudbury swarm)

*INTRUSIVE CONTACT*

PALEOPROTEROZOIC

**HURONIAN SUPERGROUP**

**Cobalt Group**

**13** **Gowganda Formation**
13a Conglomerate
13b Sandstone and arkose
13c Siltstone and argillite
13d Wacke

*UNCONFORMITY*

**12** **Mafic Intrusive Rocks (Diabase Dikes)**
12a Diabase: <1% plagioclase phenocrysts (Matachewan swarm)
12b Diabase: >1% plagioclase phenocrysts (Matachewan swarm)
12c Diabase: medium-grained, equigranular, unknown affinity

*INTRUSIVE CONTACT*

### ARCHEAN

NEOARCHEAN

**11** **Metamorphosed Calc-Alkalic Felsic and Intermediate Intrusive Rocks**
11a Massive to foliated tonalite
11b Massive to foliated monzonite and quartz monzonite
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11d Gneiss: compositional mineral layering
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11k Agmatitic-textured tonalite gneiss with rounded to angular mafic inclusions up to 40 cm in size
11l Tonalitic to dioritic metatexite: *in situ*, has melanosome rims around leucosome
11m Dioritic to tonalitic diatexite: medium-grained, homogeneous

**10** **Metamorphosed Alkalic Felsic and Intermediate Intrusive Rocks**
10a Equigranular, medium- to coarse-grained syenite
10b Monzonite, quartz monzonite

*INTRUSIVE CONTACT*

**Alkalic Metavolcanic and Related Intrusive Rocks—Timiskaming Assemblage**
7a Massive mafic and intermediate flows with biotite ± amphibole phenocrysts
7b Intermediate to felsic tuff and lapilli tuff: heterolithic, epiclastic
7c Intermediate to felsic tuff breccia: heterolithic, epiclastic
7d Trachyte flows: feldspar phenocrystic to porphyritic
7e Intermediate to felsic alkalic dikes and sills
7f Schist
7g Calc-silicate-altered alkalic rocks; chlorite-amphibole swirls, knots and veins
7h Amphibolite: grey-green, brittle rock, extensively recrystallized
7j Feldspar porphyry dikes: megacrystic, euhedral feldspar crystals up to 8 cm in size; trachytic textured

**6** **Clastic and Chemical Metasedimentary Rocks—Timiskaming Assemblage**
6a Wacke, sandstone, arkose
6b Siltstone
6c Argillite
6d Conglomerate: polymictic, clast and matrix supported
6e Schist
6f Chert
6h Pebbly conglomerate and grit

**5** **Clastic and Chemical Metasedimentary Rocks—Turbidite Related**
5a Wacke
5b Siltstone
5c Argillite
5d Graphitic and pyritic ironstone ± chert
5e Chert
5f Schist
5g Garnetiferous
5h Tuffaceous; fine- to medium-grained, feldspathic
5j Conglomerate: metavolcanic and metasedimentary clasts from 1 to 40 cm in size
5k Amphibolitic metasedimentary rocks, recrystallized
IF Iron Formation: magnetite-chert, laminated to thinly bedded

**4** **Felsic Metavolcanic Rocks**
4a Massive flows
4b Flow breccia, hyaloclastite
4p Tuff and lapilli tuff, equigranular to rarely porphyritic, white weathering[d]

**3** **Intermediate Metavolcanic Rocks**
3a Flows: massive to flow laminated
3b Pillowed flows
3c Flow top breccia and/or pillow breccia
3d Tuff and lapilli tuff
3e Schist
3f Tuff breccia and breccia: pyroclastic and epiclastic
3g Amygdaloidal
3k Feldspar porphyritic; euhedral to subhedral, white plagioclase porphyroblasts and phenocrysts to 7 mm in size
3l Amphibolite with calc-silicate alteration ± feldspar porphyroblasts
3n Gneiss: banded with mineral segregation and extensive recrystallization

**2** **Mafic Metavolcanic Rocks**
2a Massive flows
2b Pillowed flows
2c Pillow and/or flow top breccia
2d Tuff and lapilli tuff
2e Schist
2f Variolitic
2g Amygdaloidal
2h Plagioclase-bearing; may be porphyritic
2k Leucoxene-bearing
2l Amphibolite
2m Calc-silicate alteration, epidote-chlorite bands, veins, patches ± calcite veins
2n Gneiss: banded and recrystallized
2p Basaltic dikes

Ontario

Ontario Geological Survey

MAP 2677

# PRECAMBRIAN GEOLOGY

# HIGHWAY 66 AREA
# SWASTIKA TO MATACHEWAN

Scale 1:50 000

1000 m 0 1 2 km

NTS Reference: 42 A/1, 2; 41 P/15, 16

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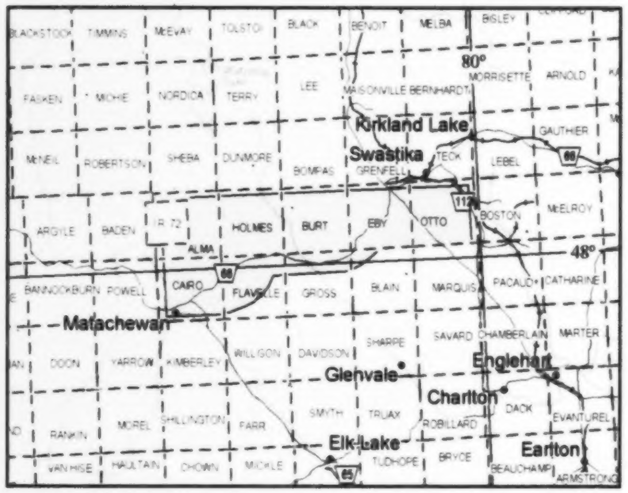


Location Map 1 cm equals 10 km

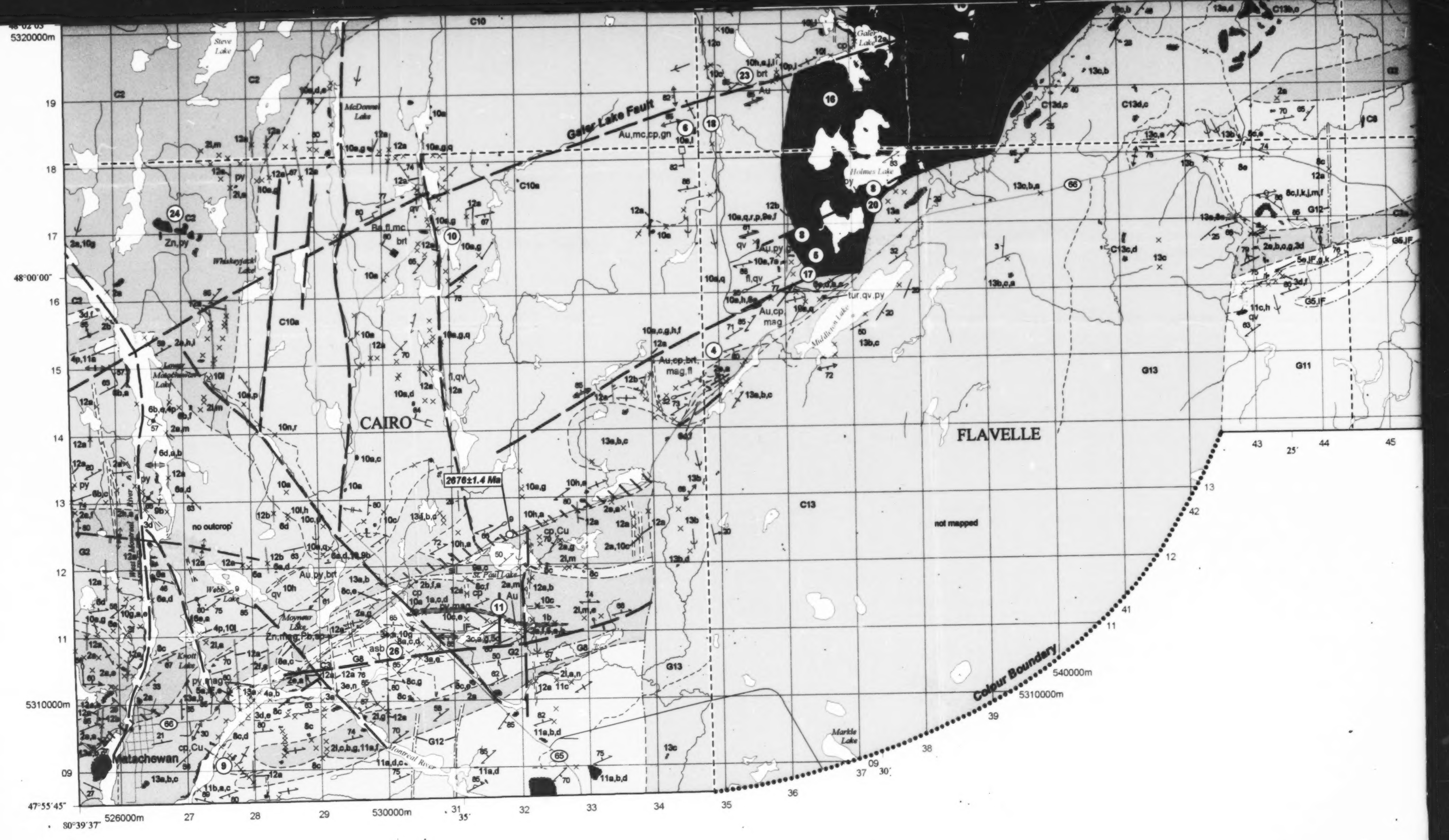
## SOURCES OF INFORMATION

Base map information derived from the Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, scale 1:20 000, with modifications by staff of the Ministry of Northern Development and Mines.

Universal Transverse Mercator (UTM) co-ordinates are in North American Datum 1983 (NAD83), Zone 17.

Ayer, J.A., Trowell, N.F. and Josey, S. 2004. Geological compilation of the Abitibi Greenstone Belt; Ontario Geological Survey, Miscellaneous Release—Data 143.

Berger, B.R. 2005. Geological synthesis of the Highway 66 area from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McDonnel Lake
Galer Lake Fault
Galer Lake
Holmes Lake
Whiskeyjack Lake
Lower Matachewan Lake
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C13c,d
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CAIRO
FLAVELLE
2676±1.4 Ma
St. Paul Lake
Webb Lake
Moyneur Lake
Knott Lake
Montreal River
Matachewan
Markle Lake
no outcrop
not mapped
Colour Boundary
Au,mc,cp,gn
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Au,cp,mag
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Zn,py
Zn,mag,Pb,sp
Au,py,brt
cp,Cu
py,mag
Ba,fl,mc
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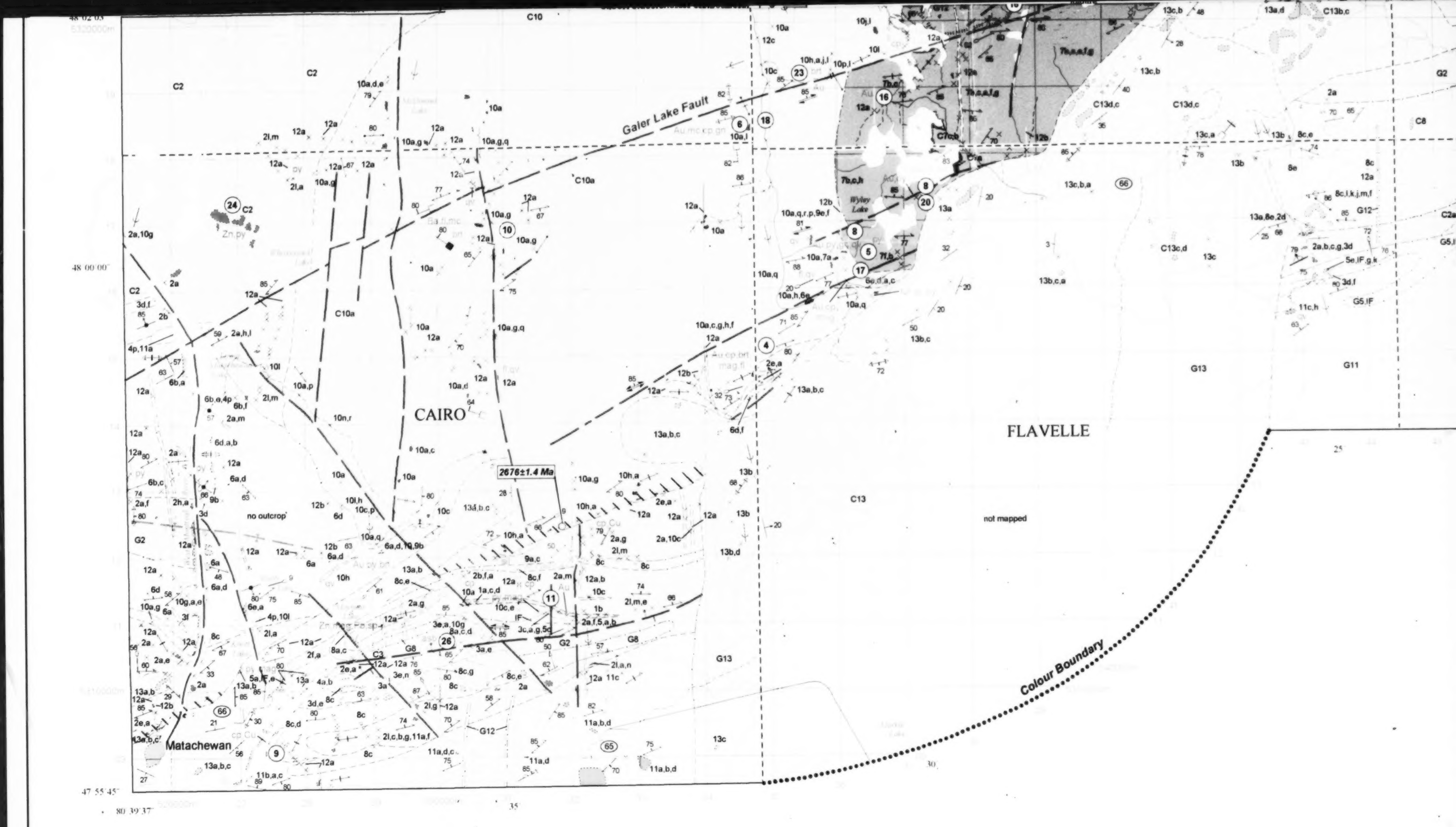
48°02'03"
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CAIRO
FLAVELLE
Galer Lake Fault
Colour Boundary
not mapped
no outcrop
2676±1.4 Ma
Matachewan
Wylsy Lake
C2
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C13
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C13c,d
C13d,c
C8
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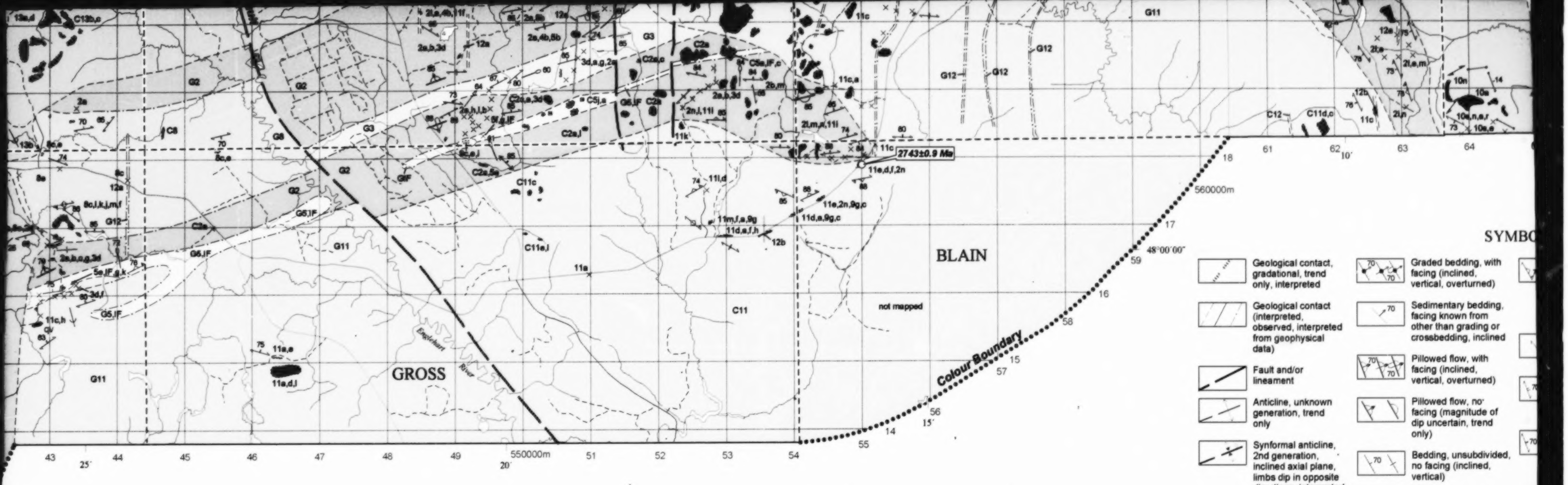
GROSS
BLAIN
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Colour Boundary
2743±0.9 Ma
Englehart River
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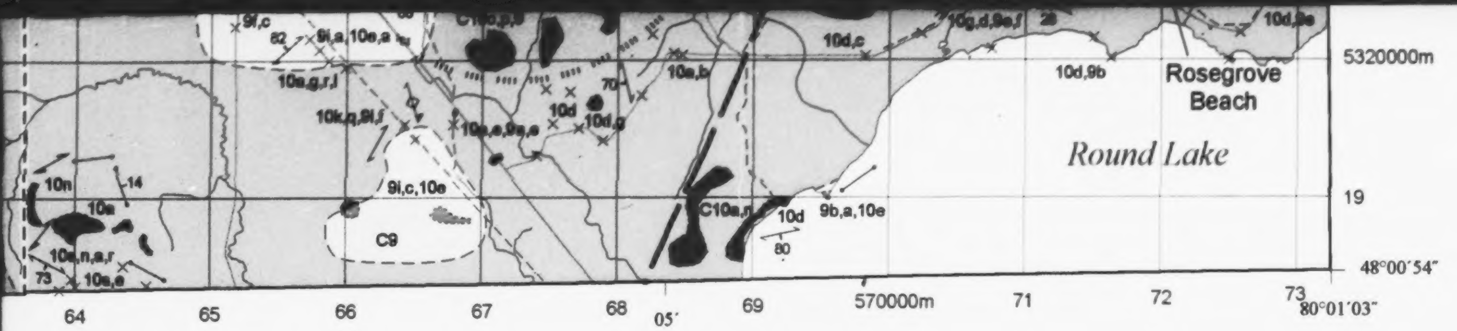
SYMBO

| | |
|---|---|
| Geological contact, gradational, trend only, interpreted | Graded bedding, with facing (inclined, vertical, overturned) |
| Geological contact (interpreted, observed, interpreted from geophysical data) | Sedimentary bedding, facing known from other than grading or crossbedding, inclined |
| Fault and/or lineament | Pillowed flow, with facing (inclined, vertical, overturned) |
| Anticline, unknown generation, trend only | Pillowed flow, no facing (magnitude of dip uncertain, trend only) |
| Synformal anticline, 2nd generation, inclined axial plane, limbs dip in opposite directions, interpreted | Bedding, unsubdivided, no facing (inclined, vertical) |
| Syncline, unknown generation, trend only | Volcanic bedding, structures other than pillows and flow tops, no facing, inclined |
| Reverse fault, unknown horizontal component, unknown generation, inclined, ball on downthrown side (interpreted) | Crenulation cleavage, unknown asymmetry, 2nd generation, vertical |
| Reverse fault, unknown horizontal component, unknown generation, inclined, ball on downthrown side (observed) | Crenulation cleavage, unknown asymmetry, unknown generation (inclined, vertical) |
| Small outcrop | General cleavage, 1st generation, inclined |
| Outcrop area | General cleavage, 2nd generation, inclined |
| Crossbedding, inclined, with facing | General cleavage, unknown generation (inclined, vertical) |



INTRUSIVE CONTACT

## SYMBOLS

d bedding, with
(inclined,
l, overturned)

nentary bedding,
known from
than grading or
bedding, inclined

ed flow, with
(inclined,
l, overturned)

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Compositional layering and parallel tectonic foliation, unknown generation (inclined, vertical, trend only)

Mineral foliation, 1st generation, inclined

Mineral foliation, 2nd generation (inclined, vertical, magnitude of dip uncertain)

Mineral foliation, unknown generation (inclined, vertical, magnitude of dip uncertain, trend only)

Igneous foliation, primary (inclined, vertical, trend only)

Igneous layering, unsubdivided, no facing (inclined, vertical, trend only)

Elongation (stretch) lineation, unknown generation

Fold axis lineation, unknown generation (U-asymmetry, Z-asymmetry)

Mineral lineation, unknown generation

Schistosity (inclined, vertical)

Brittle fault, unknown generation and vertical displacement, vertical

Reverse brittle-ductile fault, unknown horizontal displacement and generation, inclined

Shear zone, dextral, unknown generation and separation, inclined

Shear zone, unknown horizontal separation, unknown generation, inclined

Vein (quartz ± carbonate ± epidote ± sulphide), A-type, unknown generation (inclined, vertical, trend only)

Vein (barite ± quartz), B-type, unknown generation (vertical, inclined)

Vein (carbonate ± epidote), C-type, unknown generation, vertical

Glacial striae

Cadillac–Larder Lake deformation zone

2678±1.4 Ma Geochronological sample location with U/Pb age determination

Shaft

Diamond-drill hole

## PROPERTIES[a]

1. Allsopp, A. (Au, Cu) [2004]
2. Baldwin Consolidated Mines Limited (Au) [1946]
3. Bastarache, G. (Ag, Au, Cu) [2004]
4. Biralger Resources Limited (Au, Cu) [1996]
5. Brigadier Gold Limited (Au, Ag) [2004]
6. Brookbank Property (Au, Pb, Cu) [1914]
7. Cunningham, L. (Au) [1985-2004]
8. Dufresne, R. (Au, Ag, Cu) [2004]
9. Dufresne, R. and Chartre, E. (Cu) [1993]
10. Extender Mining Limited (Ba) [1979]
11. Falconbridge Limited (Au) [1986]
12. Gateford Mines Limited (Au, Ag) [1946]
13. Golden Crescent Resources Limited (Au, Ag) [1946]
14. Greater Lenora Resources Corporation (Au) [2004]
15. Keevil Mining Group Limited (Au, Cu, Fe) [1966]
16. Loki Mines Limited (Au, Ag) [1946]
17. McChesney Property (Au, Ag, Pb) [1936]
18. Minorex Limited (Au) [1978]
19. Pamorex Limited (Au) [1989]
20. Queenston Mining Incorporated (Au) [1991]
21. Reed, J. (Au) [1991]
22. Rio Tinto Canadian Exploration Limited (Au) [1980]
23. Sutton, M. (Au) [1990]
24. Tagliamonte, F. (Zn) [1995]
25. Todora Kirkland Prospecting Syndicate (Au, Cu) [1948]
26. Welsh, S. (asb) [1978]
27. Winteroad Mineral Corporation (Au) [1994]

[a] Only properties associated with significant mineral occurrences are listed. For a complete list, refer to maps P.3522, P.3534 and P.3554.

## ABBREVIATIONS

| | |
|---|---|
| asb | asbestos |
| Ag | silver |
| Au | gold |
| Ba | barium |
| brt | barite |
| cz | carbonate alteration |
| cp | chalcopyrite |
| Cu | copper |
| dia | diamond |
| fl | fluorite |
| gf | graphite |
| gn | galena |
| mag | magnetite |
| mc | malachite |
| ne | nepheline |
| Pb | lead |
| Pd | palladium |
| Pt | platinum |
| py | pyrite |
| qv | quartz vein |
| sil | silicification |
| sp | sphalerite |
| tur | tourmaline |
| Zn | zinc |

## ARCHEAN

### NEOARCHEAN

**11** ***Metamorphosed Calc-Alkalic Felsic and Intermediate Intrusive Rocks***

11a Massive to foliated tonalite
11b Massive to foliated monzonite and quartz monzonite
11c Massive to foliated granodiorite, granite
11d Gneiss: compositional mineral layering
11e Gneiss: banded and injection
11f Aplite and/or pegmatite dikes
11h Xenolith-bearing: 1 to 10% generally small (<30 cm in size) country rock
11i Equigranular to feldspar porphyritic tonalite dikes
11j Feldspar porphyritic granodiorite
11k Agmatitic-textured tonalite gneiss with rounded to angular mafic inclusions up to 40 cm in size
11l Tonalitic to dioritic metatexite: *in situ*, has melanosome rims around leucosome
11m Dioritic to tonalitic diatexite: medium-grained, homogeneous

**10** **Metamorphosed Alkalic Felsic and Intermediate Intrusive Rocks**

10a Equigranular, medium- to coarse-grained syenite
10b Monzonite, quartz monzonite
10c Alkali-feldspar granite, quartz syenite
10d "Spotted" syenite: 1 to 10% ultramafic nodules from <1 cm to 20 cm in diameter
10e Aplite dikes
10f Intrusion breccia: rounded and angular xenoliths of country rock near the contact of the Cairo stock
10g Syenitic feldspar porphry
10h Schist, mylonite
10j White to pink, fine-grained albitite
10k Syenite gneiss
10l Fine-grained, sugary-textured, aplitic syenite
10n Coarse-grained to pegmatitic syenite
10p Mesocratic to melanocratic syenite
10q Xenolith-bearing: 2 to 10% small (<30 cm in size) mafic country rock
10r Biotite-bearing: biotite crystals up to 7 mm in size and comprising up to 15% of rock
10s Potassium feldspar megacrystic syenite: crystals up to 6 cm in size; 10 to 30% amphibole and biotite in groundmass

*INTRUSIVE CONTACT*

**9** **Metamorphosed Alkalic Ultramafic and Mafic Intrusive Rocks**

9a Hornblendite and/or pyroxenite
9b Melasyenite
9c Xenolith-bearing
9d Mafic syenitic schist
9e Phlogopite-amphibole lamprophyre
9f Alkalic gabbro and/or diorite
9g Amphibole ± mica lamprophyre
9i Mica-bearing gabbro to melagabbro
9j Megacrystic amphibole, crystals up to 3 cm diameter

*INTRUSIVE CONTACT*

**Metamorphosed Tholeiitic Ultramafic and Mafic Intrusive Rocks**

8a Peridotite: massive, talc- and serpentine-bearing[c]
8c Gabbro, leucogabbro
8d Schist
8e Diorite to quartz diorite
8f Pegmatitic gabbro
8g Feldspathic aplitic dikes
8h Intrusion breccia
8j Leucogabbro
8k "Knobby" gabbro: amphibole phenocrysts and oikocrysts display positive relief on weathered surface
8l Varitextured, fine- to medium-grained gabbro[c]
8m Plagioclase porphyritic, with medium-grained, equigranular groundmass

3a Flows: massive to flow laminated
3b Pillowed flows
3c Flow top breccia and/or pillow breccia
3d Tuff and lapilli tuff
3e Schist
3f Tuff breccia and breccia: pyroclastic and epiclastic
3g Amygdaloidal
3k Feldspar porphyritic; euhedral to subhedral, white plagioclase porphyroblasts and phenocrysts to 7 mm in size
3l Amphibolite with calc-silicate alteration ± feldspar porphyroblasts
3n Gneiss: banded with mineral segregation and extensive recrystallization

**2** **Mafic Metavolcanic Rocks**

2a Massive flows
2b Pillowed flows
2c Pillow and/or flow top breccia
2d Tuff and lapilli tuff
2e Schist
2f Variolitic
2g Amygdaloidal
2h Plagioclase-bearing; may be porphyritic
2k Leucoxene-bearing
2l Amphibolite
2m Calc-silicate alteration, epidote-chlorite bands, veins, patches ± calcite veins
2n Gneiss: banded and recrystallized
2p Basaltic dikes

**Ultramafic and Mafic Metavolcanic Rocks (Komatiites)**

1a Massive flows
1b Spinifex-textured flows
1c Schist
1d Very soft, dark green komatiitic basalt
1e Flow breccia
1f Polysuture-textured flows

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[a] The letter "C" preceding a code refers to data compiled from existing maps and from maps filed for assessment work credits, and are available for viewing at the Kirkland Lake Resident Geologist's Office and from the Earth Resources and Mineral Exploration webSite (ERMES). The letter "G" preceding a code refers to data interpreted from geophysical data. The letter "D" preceding a code refers to data compiled from diamond-drill hole logs, which are available for viewing at the Kirkland Lake Resident Geologist's Office and from ERMES.

[b] Rocks codes designated with a "/" (e.g., 3/2) indicate the lithology may contain both rock types but the first number code is inferred to predominate.

[c] These rocks may, in part, be extrusive.

[d] These rocks may, in part, be intrusive.

## CREDITS

Geology by B.R. Berger, L. Pigeon, G. Leblanc and assistants, 2002 to 2004.

Digital drafting by S. Josey.

Cartographic production by S. MacLean and A. Evers

Editing by M. Rutka.

Every possible effort has been made to ensure the accuracy of the information presented on this map; however, the Ontario Ministry of Northern Development and Mines does not assume any liability for errors that may occur. Users may wish to verify critical information; sources include both the references listed here, and information on file at the Resident Geologist's Office and the Mining Recorder's Office nearest the map area.

Issued 2006.

Berger, B.R., Pigeon, L. and Leblanc, G. 2006. Precambrian geology, Highway 66 area, Swastika to Matachewan; Ontario Geological Survey, Map 2677, scale 1:50 000.

3a Flows: massive to flow laminated
3b Pillowed flows
3c Flow top breccia and/or pillow breccia
3d Tuff and lapilli tuff
3e Schist
3f Tuff breccia and breccia: pyroclastic and epiclastic
3g Amygdaloidal
3k Feldspar porphyritic; euhedral to subhedral, white plagioclase porphyroblasts and phenocrysts to 7 mm in size
3l Amphibolite with calc-silicate alteration ± feldspar porphyroblasts
3n Gneiss: banded with mineral segregation and extensive recrystallization

**2** **Mafic Metavolcanic Rocks**
2a Massive flows
2b Pillowed flows
2c Pillow and/or flow top breccia
2d Tuff and lapilli tuff
2e Schist
2f Variolitic
2g Amygdaloidal
2h Plagioclase-bearing; may be porphyritic
2k Leucoxene-bearing
2l Amphibolite
2m Calc-silicate alteration, epidote-chlorite bands, veins, patches ± calcite veins
2n Gneiss: banded and recrystallized
2p Basaltic dikes

**1** **Ultramafic and Mafic Metavolcanic Rocks (Komatiites)**
1a Massive flows
1b Spinifex-textured flows
1c Schist
1d Very soft, dark green komatiitic basalt
1e Flow breccia
1f Polysuture-textured flows

[a] The letter "C" preceding a code refers to data compiled from existing maps and from maps filed for assessment work credits, and are available for viewing at the Kirkland Lake Resident Geologist's Office and from the Earth Resources and Mineral Exploration webSite (ERMES). The letter "G" preceding a code refers to data interpreted from geophysical data. The letter "D" preceding a code refers to data compiled from diamond-drill hole logs, which are available for viewing at the Kirkland Lake Resident Geologist's Office and from ERMES.

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Matachewan
POWELL
FLAVELLE
GROSS
DOON
YARROW
KIMBERLEY
WILLISON
DAVIDSON
SHARPE
SAVARD
CHAMBERLAIN
MARTER
Glenvale
Englehart
Charlton
DACK
EVANTUREL
RANKIN
MOREL
SHILLINGTON
FARR
SMYTH
TRUAX
ROBILLARD
Elk Lake
Earlton
VAN HISE
HAULTAIN
CHOWN
NICKLE
TUDHOPE
BRYCE
BEAUCHAMP
ARMSTRONG
65

Location Map

1 cm equals 10 km

## SOURCES OF INFORMATION

Base map information derived from the Ontario Land Information Warehouse, Land Information Ontario, Ontario Ministry of Natural Resources, scale 1:20 000, with modifications by staff of the Ministry of Northern Development and Mines.

Universal Transverse Mercator (UTM) co-ordinates are in North American Datum 1983 (NAD83), Zone 17.

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Magnetic declination in the centre of the map area approximately 11°26'W in 2006.

Metric conversion factor: 1 foot = 0.3048 m.

Geology not tied to surveyed lines.

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